NEW TECHNOLOGY IN INDIA'S AGRICULTURE and Outlook for Grain Production

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ABSTRACT

India's agriculture is changing fast because of greater use of high-yielding seed varieties, insecticides, and machinery; increased multiple-cropping; and expansion of irrigated area. The rapid growth in agricultural production that characterized the late 1960's is expected to continue during the 1970's. New factories now manufacture most of the fertilizer and tractors purchased by Indian farmers. Government price policies and development programs are designed to encourage greater agricultural production. Although India's food grain production is projected to total 144 million metric tons in 1980, some imports are still likely to be needed.

Key words: India; Green Revolution; Technology; Inputs; Projections.

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Cover: A research worker investigates the growth rate of one of the 7,000 varieties of rice grown at the Central Rice Research Institute in Cuttack, India.

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PREFACE

This report discusses the impact of high-yielding seed varieties on crop production in India and the use of other inputs associated with the Green Revolution. Prospects for future gains in input use and crop production are also examined. U.S. economic aid to India during the last 20 years, valued at $10 billion, helped to initiate much of the current progress in agricultural development.

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CONTENTS

	Page
Summary	vii
Introduction	1
Soils and Land Use	1
Price and Tax Policies	4
The Impact of High-Yielding Seed Varieties	5
Wheat	5
Rice	7
Coarse Grains	9
Pulses	11
Oilseeds	11
Cotton	12
Horticultural Crops	12
Other Inputs in Indian Agriculture	14
Fertilizer	14
Manufacture	14
Imports	16
Use	18
Prices	20
Economics of Fertilizer Use	20
Irrigation	23
Farm Labor and Land Ownership	24
Machinery and Equipment	25
Tractor Manufacturing	27
Tractor Imports	29
Pesticides and Insecticides	29
Other Selected Inputs	30
Farm Credit	30
Research, Education, and Training	31
Outlook for Technological Change	31
Projections of Grain Production in India	32
Methodology and Assumptions	32
Projections	33
Literature Cited	36
Appendix Tables	38

TEXT TABLES

Page

1.--Area planted to selected crops, India, 1959/60 and 1969/70..... 2

2.--Characteristics of new rice varieties tested at Rajendranagar near Hyderabad, Andhra Pradesh, India, 1970..... 10

3.--Estimates of the share of nitrogenous fertilizer used on specified crops, India, 1970/71..... 19

4.--Prices paid by farmers for selected types of fertilizer, India, 1966 70..... 20

5.--Yields of selected varieties of wheat obtained when the optimum dose of fertilizer was applied, India, 1969/70..... 21

6.--Yields of Padma and Sabarmati rice varieties obtained when the rate and time of nitrogen application is varied, India, 1969..... 22

7.--Average yields of four varieties of grain sorghums obtained at different levels of nitrogenous fertilizer applications, India, 1969..... 22

8.--Average yields of three varieties of bajra obtained at specified levels of nitrogenous fertilizer application, India, 1969..... 23

9.--Output of 4-wheel tractors, by specified factories, India, 1965/66-1969/70..... 28

10.--Food grain production in India, 1960/61 and 1970/71, and comparison of projections for 1980/81..... 34

APPENDIX TABLES

Table		Page
1.	Selected agricultural data, India and the United States, 1970	38
2.	Share of planted area in specified crops, India, selected states, 1969/70	39
3.	Area planted to high-yielding varieties (HYV's) and traditional varieties of grains, India, 1949/50, 1960/61, and 1966/67-1970/71	40
4.	Average yields of high-yielding varieties (HYV's) and traditional varieties of grains, India, 1949/50, 1960/61, and 1966/67-1970/71	41
5.	Production from high-yielding varieties (HYV's) and traditional varieties of grain, India, 1949/50, 1960/61, and 1966/67-1970/71	42
6.	Production and imports of inorganic fertilizer, by type, selected years, 1951/52, 1970/71, and projections for 1971/72-1973/74	43
7.	Estimated output of nitrogenous fertilizer by specified plants, India, 1966/67-1970/71, and projections for 1971/72-1973/74	44
8.	Growth in the consumption of inorganic fertilizer, by type and quantity, India, 1952/53-1970/71, and projections for 1971/72	45
9.	Per hectare utilization of human labor and bullocks, India, selected areas, crops, operations, and years	46
10.	Projections of area planted, average yields, and production, high-yielding varieties (HYV's) and traditional varieties of food grains, India, 1971/72-1973/74	47
11.	Projections of area planted, average yields, and production high-yielding varieties (HYV's) and traditional varieties of food grains, India, 1980/81	48

FIGURES

Figure	Page
1.--Physical map of India	3
2.--Production of food grains from traditional and high-yielding varieties (HYV)	6
3.--Location of fertilizer and tractor factories	17
4.--Consumption of inorganic fertilizer	18
5.--Fertilizer and tractor use and the production of high-yielding varieties (HYV) of cereals	28

SUMMARY

Technology in India's agricultural production since the drought of 1966 has resulted in increased crop yields and a more favorable food situation. The most significant gains have been made in grain production, which rose from 66 million tons in 1966/67 to 96 million tons in 1970/71.* Grain imports during this period declined from 9.4 million to 2.5 million tons.

Agricultural production has increased primarily because farmers are making greater use of high-yielding seed varieties. Use of this input is being accompanied by increased use of fertilizer, insecticides, and farm machinery; by an expansion of irrigated area; and by the practice of multiple-cropping. Favorable Government price policies and programs have been highly instrumental in encouraging farmers to use these inputs.

During 1966/67-1970/71, the area planted to high-yielding grain varieties increased from 1.8 million to 15.1 million hectares, with the high-yielding varieties' share of total grain production rising from 6 to 35 percent. High-yielding varieties of wheat and bajra (spiked millet) produce average yields that are about four times those for traditional varieties, while yields from high-yielding rice varieties are more than double those for traditional varieties. Use of high-yielding grain varieties has now spread to all agricultural areas in India.

Total fertilizer use in India increased from 305,000 tons in 1959/60 to 2.2 million tons in 1970/71. Grains receive about two-thirds of all nitrogen applications and over half of phosphate and potash applications. However, over half the area planted to grains receives no chemical fertilizer. Because of high distribution costs and taxes, fertilizer prices have tended to rise in recent years in India, keeping the rate of application generally well below the optimum rate.

Pesticides were used on about 45 million hectares in 1970/71, compared with only 2.4 million hectares in 1955/56. Marked gains in output of pesticides by domestic factories have reduced the need for imported products. Insecticides have helped farmers to more effectively control pests attacking rice and cotton in the last several years.

Tractor numbers are increasing at the rate of 40,000 annually. They have contributed to farm productivity by permitting timeliness in farm operations and improved cultivation. Labor displacement resulting from use of tractors is possibly an unfavorable aspect of this increased mechanization.

Next to the People's Republic of China, India has the world's largest amount of irrigated cropland. In 1970/71, about 23 percent of the total crop-

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* All tons are metric.

land--32 million hectares--was irrigated, compared with 16 percent in 1950/51. Slightly over half the irrigated area is planted to high-yielding seed varieties.

The practice of multiple-cropping has been facilitated by wider use of quick-maturing wheat and rice varieties. During 1966/67-1970/71, the area in multiple-cropping increased by about 1 million hectares annually.

As a result of these increases in agricultural technology, average yields for all grain crops are now about one-third higher than they were 5 years ago. Yields of wheat and bajra have increased by more than 20 percent since 1966, while those for rice have increased by nearly one-third.

India's Fourth Five-Year Plan (1969/70-1973/74) calls for food grain production to reach 129 million tons in 1973/74. However, plans to use 5.5 million nutrient tons of fertilizer to achieve that goal cannot be fulfilled because a number of new fertilizer factories which were planned have not been built and existing factories produce less than 60 percent of their capacity. Actual food grain production in 1973/74 is more likely to approximate 123 million tons.

Projections made in this study for grain production in India assume further gains in agricultural technology. Production of milled rice in 1980/81 should approximate 58 million tons. Wheat production should reach nearly 32 million tons, while coarse grains production should approximate 39 million tons. Except for the coarse grains projection, these projections are close to projections made in other studies. Most coarse grains projections in earlier studies are lower than in this study, because the impact of technology on corn and bajra production was not significant until 1970/71.

NEW TECHNOLOGY IN INDIA'S AGRICULTURE
and Outlook for Grain Production

by

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INTRODUCTION

The spectre of widespread malnutrition and famine has plagued India for many years. Only recently has the introduction of high-yielding wheat and rice varieties--together with family planning programs--offered any hope of winning a battle against overwhelming odds.

High procurement prices continue to provide an incentive for commercial farmers to produce food grains. Farm purchasing power has increased so markedly that some of the fastest growing industries in India manufacture agricultural inputs. The expanding fertilizer industry is a key to greater productivity.

The new technology in India's agriculture can prove to be "problem creating" as well as "problem solving." Introduction of new technology has the potential for displacing large numbers of workers. With large population increases, however, India must continue to absorb workers in the agricultural sector despite the fact that unemployment and underemployment are already serious problems in some rural areas.

SOILS AND LAND USE

Alluvial soils cover most of the Gangetic Plain and some coastal areas of India (fig. 1 shows geographic and political delineations of India). For centuries, these alluvial soils have supported a large population, and much of the original fertility has disappeared. However, the soils are highly responsive to water and fertilizer. In some areas, silt from flooding replenishes the fertility of the soil. Black soils, which spread from Gujarat to Andhra Pradesh, do not have the excellent texture of most sandy loam and alluvial soils. Red loam soils predominate in central India, and red sandy soils are found in much of southern India.

About one-sixth of India's cropland is left fallow each season to help restore fertility. Organic matter--including animal manure--is added to improve soil fertility and texture.

Food grains, which in India include all cereals and pulses, are planted on about three-fourths of the cropland (table 1). Rice, wheat, grain sorghum, and pulses are the most important food grain crops.

Table 1.--Area planted to selected crops, India, 1959/60 and 1969/70 1/

Crop	Area		Percentage distribution	
	1959/60	1969/70	1959/60	1969/70
	1,000 hectares		Percent	
Rice	33,820	37,680	22.1	23.4
Wheat	13,380	16,626	8.8	10.3
Grain sorghum	17,707	18,605	11.6	11.5
Millets	18,361	20,009	12.0	12.4
Corn	4,344	5,862	2.8	3.6
Barley	3,378	2,765	2.2	1.7
Pulses	24,833	22,023	16.3	13.7
Food grains	115,823	123,570	75.8	76.6
Peanuts	6,442	7,219	4.2	4.5
Cotton	7,295	7,712	4.8	4.8
Sugarcane	2,137	2,718	1.4	1.7
Jute	682	770	0.4	0.5
Other crops	20,445	19,245	13.4	11.9
Total	152,824	161,234	100.0	100.0

1/ Crop years beginning July 1. Detailed data on food grain production are presented in app. table 2.

Source: (8). Underscored numbers in parentheses refer to references listed at the end of this report.

Oilseeds occupy about one-tenth of India's cropland, and cotton occupies about 5 percent. Tea, coffee, and other plantation crops occupy less than 1 percent of the cropland, although they comprise over 40 percent of India's agricultural exports.

Multiple-cropping--the practice of producing more than one crop on a plot of land within 1 year--has made a significant contribution to India's crop production. It has provided farmers with a new tool in managing their limited resources to boost output. Multiple-cropping has been facilitated mainly by wider use of high-yielding, quick-maturing varieties of grain. A corollary to this development has been an increased need for mechanization (to assure timeliness in harvesting and planting) and expanded fertilizer use (to supply additional soil nutrients to increase output per unit of area).

In the early 1960's, the area covered by multiple-cropping in India averaged about 23 million hectares annually. It declined by more than 10 percent during the droughts of 1965 and 1966. Since that time, the area covered by multiple-cropping has increased by about 1 million hectares annually and

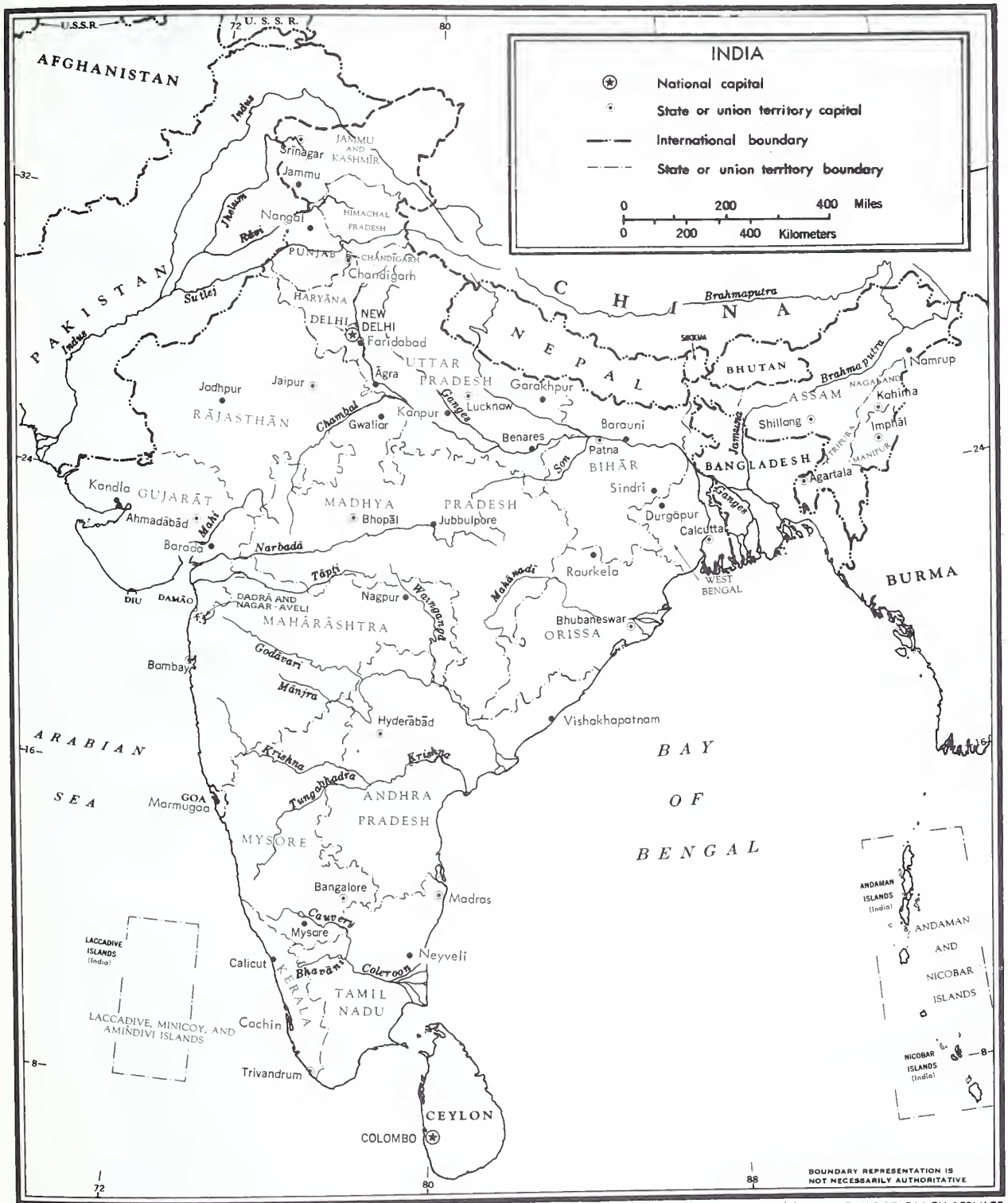

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Figure 1

approximated 25 million hectares in 1970/71. The expansion of multiple-cropping has been particularly rapid on rice farms in coastal areas of southern India.

Industry in India, particularly heavy industry, received top priority in the Government's Second and Third Five-Year Plans, covering, respectively, 1956/57-1960/61 and 1961/62-1965/66. During these periods, the agricultural growth rate slowed and supplies of inputs to the farm sector fell far short of the Plans' targets.

Fertilizer output increased slowly and the 2 consecutive years of drought--1965 and 1966--prompted imports of fertilizer on an urgent basis. Because of shortcomings in agricultural production caused by the droughts, India delayed initiating the Fourth Five-Year Plan, and annual plans were implemented for 1966/67-1968/69. With ample supplies of imported fertilizer, expanded use of high-yielding seed varieties, and unusually good rainfall, food grain production reached 95 million tons in 1967/68, 21 million tons above the previous season's level. 1/ Sharp changes in price policy, large grain imports, and adverse weather during the mid-1960's caused planners to give greater attention to agriculture in preparing the Fourth Five-Year Plan (1969/70-1973/74) (11).2/

PRICE AND TAX POLICIES

In the 1950's and early 1960's, agricultural inputs in India were subsidized by the Government. Subsidies were necessary because farmers were suspicious of the merits of new agricultural inputs and because prices of commodities were relatively low.

In 1965, the minimum procurement price of wheat increased, causing a dramatic increase in wheat production. Since then, prices for corn, grain sorghum, and millets have increased because of higher procurement prices. Open market prices for cotton, sugar, and peanuts have also increased significantly.

Thousands of demonstration plots, displayed by extension agents and agricultural universities, convinced many farmers that they could increase crop production by using high-yielding seed varieties along with other inputs such as fertilizer, machinery, insecticides, and pesticides. The 2 years of drought resulted in substantial debts for the farmers and increased their interest in new farming methods. Between 1965 and 1969, the reluctance of larger farmers to use new or additional inputs gave way to eagerness for them. The Green Revolution has now spread to all areas of the country. 3/

1/ All tons are metric.

2/ Underscored numbers in parentheses refer to references listed at the end of this report.

3/ The Green Revolution is the name frequently used for the change brought about in the agriculture of less developed countries by the use of high-yielding seed varieties and other agricultural inputs new to these countries.

Minimum procurement prices, usually higher than support prices, serve as guaranteed prices to the farmer. Further, private traders usually pay farmers more than the minimum procurement price. If they do not, the grain is usually marketed in the State Procurement Center, which is under the supervision of the Food Corporation of India. Grain procurement prices vary by type and grade of grain (these prices are discussed in detail later in this report in the individual grain sections).

In March 1969, the Government imposed a levy on fertilizer, although fertilizer mixtures were exempted. Various states have levied sales taxes on fertilizer, ranging from 2 to 7 percent of the price. Some municipalities and districts have also taxed fertilizer (3).

Since 1969, a 20-percent excise tax has been imposed on purchases of pumps used for irrigation. Excise taxes on tractors were implemented in 1969/70 and have ranged between 7 and 10 percent of the purchase price.

THE IMPACT OF HIGH-YIELDING SEED VARIETIES

In India, the area planted to high-yielding grain varieties increased from about 1.8 million hectares in 1966/67 to 15.1 million hectares in 1970/71, rising from nearly 2 to 15 percent of the total area planted to grains (app. table 3). The share of grain production provided by high-yielding varieties increased from 5.5 percent in 1966/67 to about 35 percent in 1970/71 (app. table 5). Success with new wheat varieties in the Gangetic Plain and with new rice varieties is encouraging scientists to search for improved varieties of pulses, cotton, oilseeds, and horticulture crops.

The Government of India, the U.S. Agency for International Development, various foundations and universities, and private individuals have been instrumental in testing, adapting, and providing new cereal varieties for use in India. The push to find new high-yielding rice varieties that resist diseases and suit consumer taste is currently a major undertaking.

The National Seeds Corporation of India has several laboratories, and thousands of inspectors for testing seed purchased under contract from farmers. The corporation also provides storage facilities for the farmers. In some villages, especially in Kashmir, farmers are engaged solely in seed production. Contracts for farmers to produce wheat seed have provided excellent profit opportunities for efficient growers in the Punjab and Uttar Pradesh. Some of these same farmers produce hybrid corn seed during the summer. Pantnagar is a center for producing soybean seed. The Seeds Act of 1966 empowers the Government of India, in consultation with the Central Seed Committee, to control the kinds and varieties of seed eligible for sale in specific areas (7, Oct. 1970).

Wheat

Wheat production in India increased from 10.4 million tons in 1965/66 to about 23.2 million tons in 1970/71. Output provided by high-yielding varieties jumped from 1.3 million tons in 1966/67 to about 15.6 million tons in 1970/71,

while output provided by traditional varieties declined from 10 million to 7.6 million tons (app. table 5). During 1966/67-1970/71, the share of total wheat production from high-yielding varieties rose from 11 to 67 percent (fig. 2).

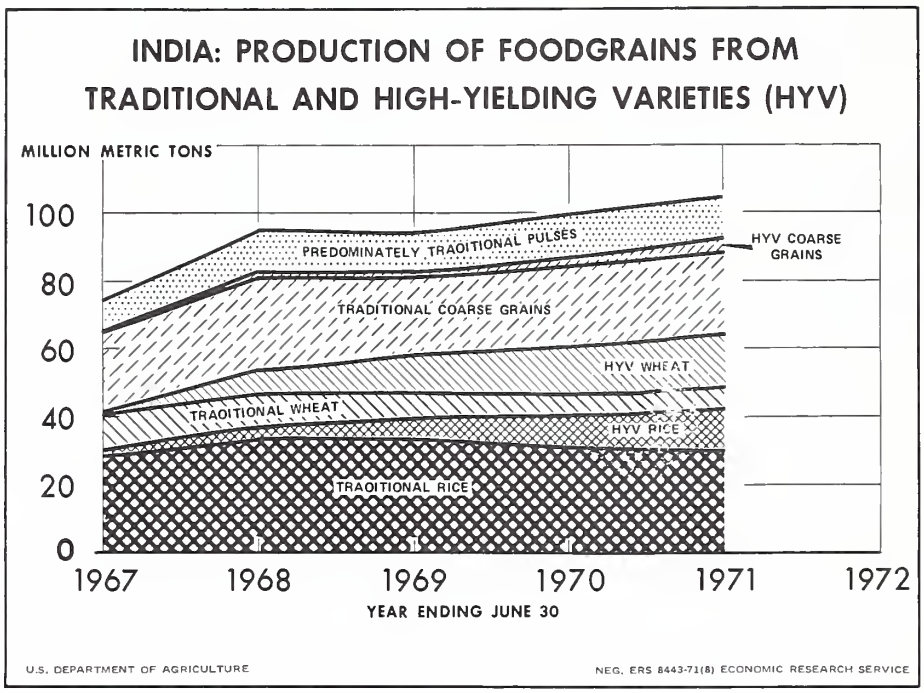


Figure 2

The phenomenal increase in wheat production resulted from extensive use of high-yielding seed varieties, fertilizer, improved practices, and high procurement prices. Because high-yielding wheat varieties planted on irrigated land respond well to fertilizer, they produce yields which are much higher than those for traditional varieties grown on the same irrigated and fertilized land (7). Since 1966, minimum procurement prices for wheat have ranged from $2.40 to $2.94 per bushel (22).

Area planted to high-yielding wheat varieties increased from 514,000 hectares in 1966/67 to about 6.2 million hectares in 1970/71, or rising from 4 to nearly 35 percent of the total wheat area (app. table 3). About 1 million hectares of irrigated land remain planted to traditional wheat varieties. Practically all of the high-yielding varieties have been planted on irrigated land, although some new varieties have been developed especially for dry land areas. Because premium prices are paid for some traditional white varieties that are preferred by consumers, complete coverage of irrigated land by Mexican and Indian high-yielding varieties is unlikely.

In the summer of 1965, India imported 250 tons of Mexican wheat seed. Under contract with the National Seeds Corporation, seed farmers in Uttar Pradesh and the Punjab used the imported seed to produce about 15,000 tons of seed for distribution in 1966/67. In the autumn of 1966, 18,000 tons of Mexican wheat

seed were imported; from these imports and from domestic supplies, about 33,000 tons of the Mexican seed varieties were distributed to farmers in 1966/67. Sonora 64 and Lerma Rojo were the leading Mexican varieties imported.

Sonora 64, the short-stemmed Mexican wheat variety, was tested at research stations in Delhi, Ludhiana, and Pantnagar in the early 1960's. The Punjab Agricultural University in Ludhiana and the Agricultural University of Uttar Pradesh in Pantnagar greatly increased their research activities in testing wheat varieties in the mid-1960's.

Crosses between Mexican wheat varieties and those native to India have recently provided high-yielding varieties that have excellent quality, an amber color, and high yields. An amber-colored, high-protein strain of wheat has been developed by treating Sonora 64 with gamma rays and has been released under the name of Sharbati-Sonora.

In recent years, Uttar Pradesh has led in the production of high-yielding wheat varieties. Production of new varieties in the Punjab and in Bihar has also increased rapidly. Wheat production has also increased outside traditional growing areas, especially in West Bengal and Rajasthan.

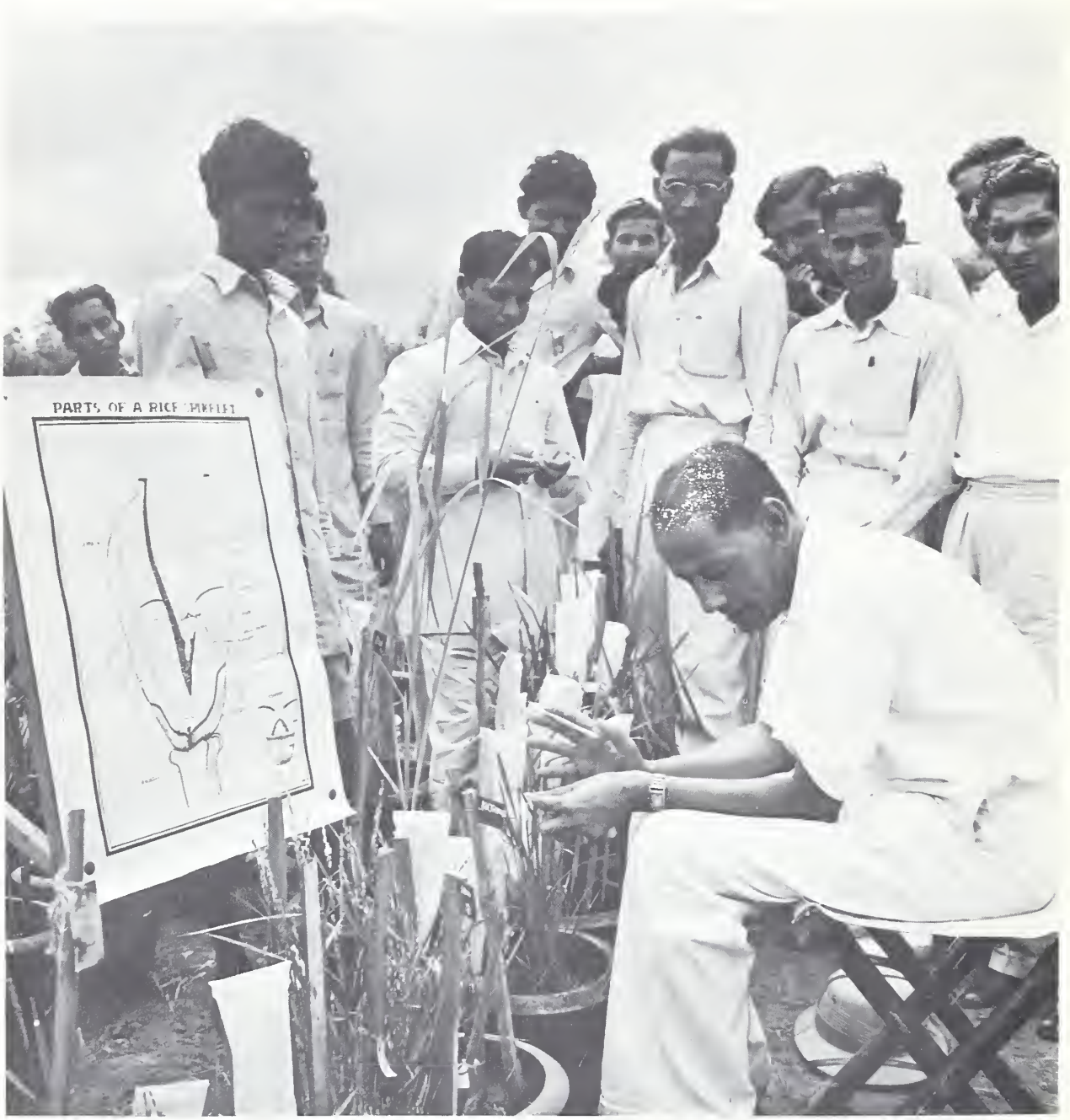
Research to develop new high-yielding wheat varieties for use on nonirrigated land has resulted in the release of two new varieties. Narabanda 4, released by the All-India Wheat Research Workers Workshop in 1970, shows more response to fertilizer than most traditional varieties and is expected to lead to some improvement in yields. A durum wheat, A-9-30-1--which was also released recently--should help dryland farmers to increase their wheat yields (7, Nov. 1970).

The recent release of a new triple-dwarf and rust-resistant variety, Hira, is expected to enable farmers to boost their yields beyond those currently being obtained from the favorite Mexican varieties. Hira, a high-quality, amber-colored wheat, produces yields that range from about 15 to 20 percent higher than Kalyan Sona, a widely planted Mexican variety (7, Nov. 1970).

Rice

Plans for a dramatic breakthrough in rice production in India have not materialized because of disease problems, reluctance of some small farmers to accept new technology, and poor consumer acceptance of certain new varieties. Yet, a gradual improvement in rice yields has occurred and prospects for further gains are promising. High-yielding varieties were planted on about 5.5 million of the 37.4 million hectares of rice planted in 1970/71 (app. table 3), accounting for about 28 percent of the total harvest (app. table 5). Total rice production increased from about 30.4 million tons in 1966/67 to 42.4 million tons in 1970/71.

The Central Rice Research Institute in Cuttack, Orissa, has conducted tests on yields and growth characteristics of over 7,000 varieties of rice. More area is still planted to IR-8 than to any other high-yielding rice variety. However, newer varieties have been released which provide higher yields, better quality



New varieties of rice that provide high yields, improved quality, and more resistance to diseases and pests are introduced to farmers after intensive testing by experiment stations.

grain, and more resistance to certain pests (7, Aug. 1971). ADT-27, developed at Cuttack, provides farmers in the Tanjore District of Tamil Nadu with excellent yields. Taichung Native I and a tall Indian variety were used to develop a new high-yielding variety called Jaya, which was released in 1969. Vijaya and IR-20 are popular new rice varieties because of their quality and resistance to pests and certain diseases (table 2).

Most traditional varieties of rice grown in India belong to the Indica group. They are adaptable to conditions of variable monsoon rainfall, low soil fertility, and warm tropical temperatures. Most Indian varieties resist prevalent insects and diseases. They also can grow strong enough to compete effectively with weeds for plant nutrients. Indica rice varieties can be cooked dry or fried in various ways. Characteristics which enable these varieties to survive under tropical conditions in India--tall growth, long drooping leaves, and late maturity--become liabilities when certain improved farming practices are implemented (1). Under heavy fertilization and constant irrigation, for example, Indica varieties become victims of lodging and show little yield increase (8), (23).

Japonica varieties have evolved through an intensive selection process. Compared with the Indica varieties, they have darker and more upright leaves, a shorter and stiffer stalk, earlier maturity, and a more thrifty vegetable growth. They respond well to fertilizer and improved cultural practices. However, most of them are more susceptible than the Indica varieties to insects and virus diseases of the tropics, especially during hot monsoon weather (1). After years of research, some new varieties have been developed which show high resistance to certain pests and diseases (table 2).

Jalmagna is a new deep-water rice variety released by the Uttar Pradesh Department of Agriculture in 1970. Plant height varies from about 5 to 23 feet depending upon the depth of the water where the plant is grown. The plant has a capacity to keep pace with a rise in water level, with the healthy green leaves floating on the surface of the water. Yields obtained at Bahraich, Uttar Pradesh, in 1968 and 1969 were about 4.2 tons of paddy per hectare.

Numerous other new rice varieties are planted in India. Two new varieties, Pankaja and Jagannath, can be cultivated in water-logged soils (7, Oct. 1971). They also have an ability to withstand a certain degree of soil salinity. Sabasmati has proved suitable for the drier area of northwestern India. Jamuna has been grown successfully in rain-fed areas of Andhra Pradesh, and Bala has done well in upland areas. The short growing season of Bala has caused it to be a favorite among farmers who practice double-cropping. Krishna has done well in Uttar Pradesh, Madhya Pradesh, and Gujarat. Yields for some plots of Vijaya have been higher than those of IR-8 under similar growing conditions and levels of fertilization (7, Sept. 1971).

Coarse Grains

The area in India planted to high-yielding varieties of grain sorghums, corn, and millets increased from 390,000 hectares in 1966/67 to about 3.4 million hectares in 1970/71 (app. table 3). Production from high-yielding varieties

Table 2.--Characteristics of new rice varieties tested at Rajendranagar near Hyderabad, Andhra Pradesh, India, 1970

Variety	Days to maturity	Grain quality	Year of release	Yield--kilograms per hectare	Reaction to 1/					
					Pests		Diseases			
					Stem borer	Leaf hoppers	Blast	Bacterial leaf blight	Helmintho-sporium	Tungro virus
Bala	90-110	Coarse	1970	3,142	S	S	S	S	MR	S
Cauvery	"	Fine	1970	4,300	S	S	S	S	MR	S
Padma	110-130	Coarse	1968	4,135	S	HS	S	HS	MR	HS
Kanchi	"	Coarse	1970	4,176	S	S	S	HS	MR	S
Ratna	"	Fine	1970	5,441	MR	S	MR	S	S	S
Krishna	"	Fine	1970	4,218	S	S	NT	S	MR	S
Sabarmati	"	Fine	1970	3,608	S	S	MR	S	S	S
Jamuna	"	Fine	1970	4,140	S	S	NT	S	S	S
Jaya	130-150	Coarse	1968	5,727	S	MR	R	MS	S	MS
IR-8	"	Coarse	1966	5,442	S	MR	R	MS	S	MS
Ir-20	"	Fine	1970	5,326	MR	MR	R	MR	S	MR
Vijaya	"	Fine	1970	5,269	S	R	R	MR	S	MR

Note: All plots were irrigated and 100 kilograms of nitrogen were applied per hectare.

1/ R = resistant; MR = moderately resistant; S = susceptible; MS = moderately susceptible; HS = highly susceptible; NT = not tested.

Source: (8, article by S.V.S. Shastory and W. H. Freeman, Sept. 1971).

of coarse grains increased from about 640,000 tons to about 6 million tons during the same period (app. table 4).

Area planted to improved varieties of grain sorghums increased tenfold during 1966-70. Yields of two improved varieties, Swarna and CSH II, are about 50 percent above those for traditional varieties in tests where 100 kilograms of nitrogen are applied to all plots (3).

Corn production increased sharply to 7.4 million tons in 1970/71, with high-yielding varieties accounting for about 14 percent of total production. Production increases were highest in the irrigated areas of Rajasthan and Madhya Pradesh (9). Vikram, Vijay, and Ganga 3 are popular hybrid varieties.

Research is being conducted on higher yielding varieties of millets. At the Agricultural College and Research Institute in Comimbatore, Tamil Nadu, different varieties of ragi are being tested. High-yielding varieties account for about 40 percent of the bajra (spiked millet) harvest.

Pulses

In India, per capita supplies of pulses declined from 25.1 kilograms in 1961 to 16.9 in 1970. A shift from pulses to wheat has been marked since 1965. The total area planted to pulses declined from about 24 million hectares annually in the early 1960's to 21 million hectares in 1970.

A Coordinated Pulses Scheme, established in 1967, involves the cooperation of the U.S. Agency for International Development, agricultural universities, and departments of state governments concerned with agriculture. With the objective of finding ways to increase pulse production, these organizations conduct research in plant breeding, plant pathology, entomology, agronomy, and other scientific fields. Because of the nutritional value of pulses, production of this crop is expected to receive higher priority in the 1970's (7, Nov. 1971).

Research has indicated that pulse varieties exist which would enable Indian farmers to greatly increase their pulse yields. Also, tests have indicated that yields can be improved by planting new, improved, quick-maturing varieties and using fertilizer (7, Oct. 1971). Pulses also fit well into multiple-cropping rotations.

Oilseeds

Use of improved varieties of oilseeds will probably increase in India in the next few years. The shortage of vegetable oils since 1965 has been caused by lagging output of oilseed crops and by growing consumer demand for cooking oil. India's production of oilseed crops increased in 1970/71, with strong gains in peanuts, soybeans, rapeseed, mustard seed, safflower, and castor beans.

Peanut production declined to 5.5 million tons in 1971/72 because of dry weather in western India. Research is underway to determine which foreign

varieties might succeed under Indian growing conditions. The Indian Oilseed Development Council has conducted some of these tests, but most are conducted by the Indian Council of Agricultural Research (ICAR). Asiriya Msitunde, a variety imported from Tanzania, has become popular among farmers in Mysore and Andhra Pradesh. Junagadh-11, a drought-resistant variety, has been planted by some farmers in Maharashtra and Gujarat. Demonstration plots have been located in major peanut-growing areas by ICAR to illustrate benefits from the new varieties and improved cultural practices.

In the late 1960's, less than 4 percent of the peanut area was irrigated but it is expanding, mostly because of expansion in multiple-cropping. Prices of almost $200 per ton have encouraged farmers to plant more peanuts on irrigated land. In northwestern India, rapid-maturing peanut varieties such as T-64 and AK 12-24 can be planted after wheat is harvested. They are replacing some slow-maturing varieties in progressive farm areas.

The search for a summer oilseed crop for planting in wheat areas and the continuation of high vegetable oil prices caused planners at Pantnagar, Uttar Pradesh, to explore the possibilities of commercial soybean production. At the research station there, soybean varieties from all over the world have been tested for their performance under Indian growing conditions. Tests conducted by ICAR in Uttar Pradesh indicated that Bragg, Hardee, and Semmes provided yields ranging from 3 to 4 tons per hectare. Trial plantings of soybeans have also been made at a number of research stations in northern India. The University of Illinois provides experts for the All-India Coordinated Project on Soybeans, which started functioning in 1967.

Cotton

The All-India Coordinated Cotton Improvement Project, managed by the ICAR of New Delhi, will receive about $20 million during the Fourth Five-Year Plan for all aspects of research on cotton production. A major objective of plant breeders will be to develop new cotton varieties that have desirable milling qualities, high yields, and disease resistance. Three American-type varieties were recently tested by the experiment station at Comimbatore, Tamil Nadu. MCU-5 was the superior new strain in the tests conducted there. It yields about 650 kilograms of lint per hectare and matures in 165 days (7, May 1970).

Sujata, a new variety from Egypt, has the best spinning quality of any variety so far released for cultivation by Indian farmers. It has a resistance to blackarm and the new wilt disease spreading among North American varieties in southern India. A promising variety, Hybrid 4, has helped farmers to improve cotton yields in Gujarat.

Horticultural Crops

Vegetable output in India has doubled in the last 20 years, partly because of greater use of improved varieties and fertilizer. Progress has been most

rapid near cities and in those irrigated areas where multiple-cropping is becoming popular.

Research on fertilizer response at various levels of application and on different soil types has provided useful data on how to increase yields of selected traditional varieties of onions, eggplant, garden peas, and cowpeas. Tests using North American and European high-yielding varieties of tomatoes, eggplant, onions, melons, pumpkins, cucumbers, and some other vegetables have evaluated their performance under Indian growing conditions (7).

India's imports of vegetable seed in the late 1960's were small because of the low priority given to vegetables by planners and a policy of depending predominately upon domestic seed developers and growers for supplies. The vegetable seed industry has flourished in Kashmir because of the climate, the availability of persons trained in seed production, and efforts by farmers to intensify their labor input to maximize their income from small irrigated plots.

Researchers have found grape varieties that are highly productive in irrigated areas of the Deccan Plateau. The popular variety, Aneshabi, ripens in March. Cold storage facilities are being built to enable India to export more grapes. Research to develop new varieties for southern highlands and the Punjab is underway. Grape production in India has already increased from 44,000 tons in 1961 to about 200,000 tons in 1971.

Dwarf varieties of apples are gaining in popularity in Kulu Valley, Himachal Pradesh. The traditional Ambri variety in Kashmir is being replaced by new U.S. varieties of dwarf apples, especially Golden Delicious and some winter varieties with excellent keeping qualities. Varieties of pears which are blight resistant can be grown in the foothills of the Punjab, where blight once did severe damage during the monsoon. Research is underway in Himachal Pradesh to find varieties of plums, cherries, and peaches that will produce high yields in the foothills of the Himalayas. Dwarf peach varieties that ripen before the heavy monsoon rains begin are preferred by orchardists in Uttar Pradesh.

Research to find suitable almond varieties for slopes too steep for grains is underway in Himachal Pradesh. Tests are being conducted at Comimbatore on ways of improving yields of cashew nuts. New varieties of pistachio nuts from California could open up opportunities for producing that crop in some areas of Rajasthan.

ICAR has conducted extensive research to develop mango varieties that bear heavy crops each year. Most traditional varieties alternate with good and poor yields. A cross between dwarf Dashehri and Neelum has produced a new variety which gives heavy crops every year.

OTHER INPUTS IN INDIAN AGRICULTURE

The success of high-yielding seed varieties in expanding crop output is closely correlated with the use of other inputs. This is why programs to promote grain production have emphasized a "package arrangement" which includes other inputs as well as high-yielding varieties of seeds.

Fertilizer

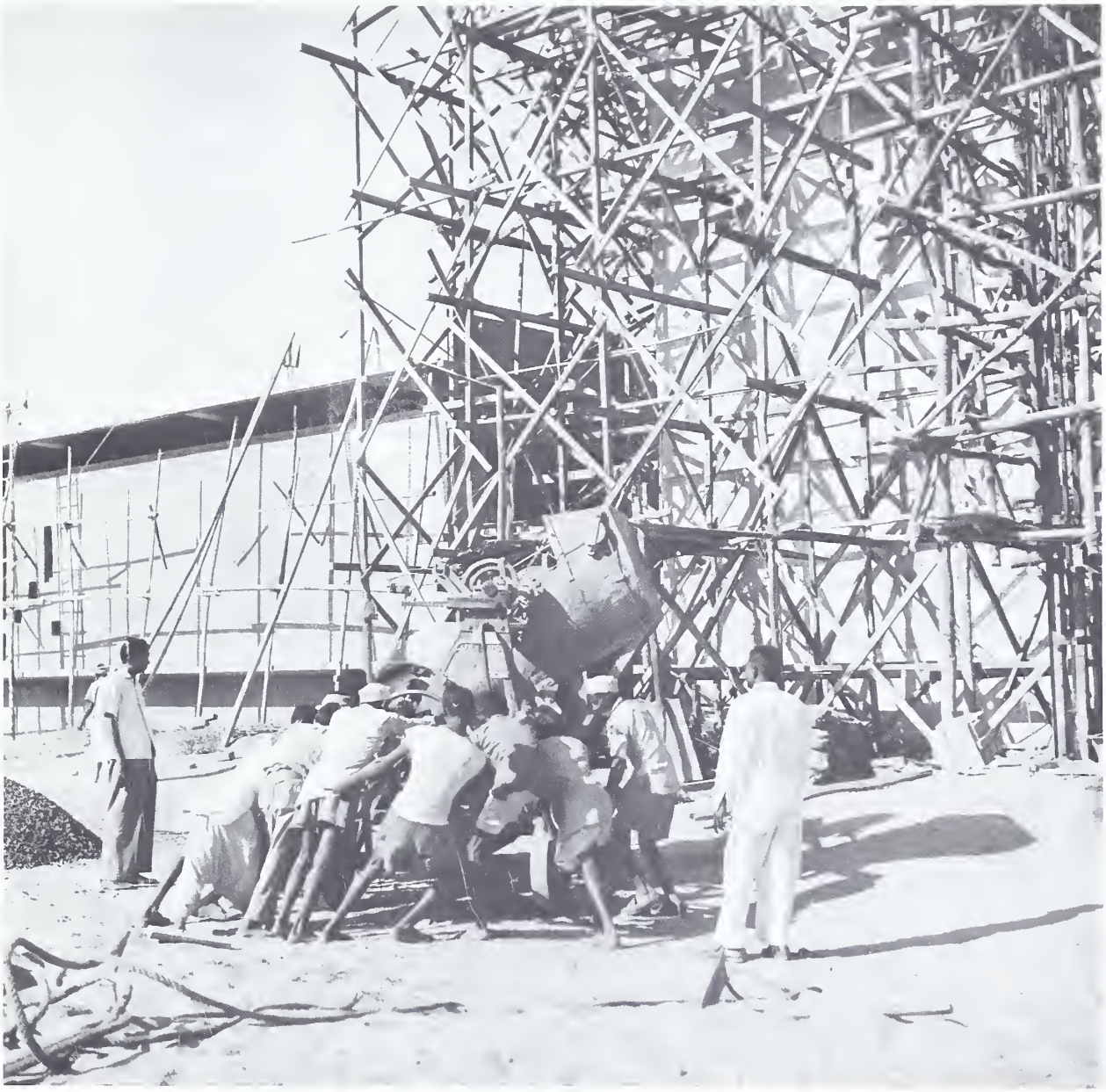
Fertilizer will be a key input in determining India's agricultural growth rate in the early 1970's. While domestic production and consumption of fertilizer continue to rise, the targets set in Government plans have been consistently higher than actual achievement (12). Fertilizer imports continue to decline as domestic manufacturers provide a larger share of the supply. Expansion of the domestic fertilizer industry, however, has been slowed by raw material shortages and other constraints such as electrical power failures. Naphtha, a byproduct of petroleum refining, is the major raw material used in about 70 percent of India's nitrogenous fertilizer. The supply of Naphtha is seldom sufficient to allow fertilizer factories to operate at full capacity (3, Jan. 1971).

Tests have indicated that if crop yields in India are to increase, almost all soils need additional nitrogen, about 85 percent need additional phosphorus, and over 60 percent need potash (3, Jan. 1971). Use of high-yielding seed varieties and the practice of multiple-cropping with two grain crops a year has depleted some soils of essential minor elements. Thus, demand for fertilizer is expected to grow rapidly and total use of plant nutrients is likely to double during 1972-76 (3, Jan. 1971).

Manufacture

The poor performance of fertilizer manufacturing during the Third Five-Year Plan (1961/62-1965/66), together with severe food shortages during 1965 and 1966, caused India to seek foreign investors in its fertilizer industry.4/ Foreign firms that arranged to begin building fertilizer factories before December 31, 1967, were given certain product price guarantees by the Government of India (3). Investments by foreign firms and new factories brought into operation by the Fertilizer Corporation of India (FCI) caused fertilizer output to rise markedly in the 1960's and imports to decline (app. table 6).

4/ The Plan's production target for nitrogenous fertilizer output in 1965/66 was reduced from 1 million nutrient tons to 800,000 tons. Actual production that year was only 238,000 tons. The shocking shortfall made it evident that a crash program for attracting new investments into the fertilizer industry was needed.



New factories now provide over half the fertilizer used by Indian farmers. New warehouses have also been built to store fertilizer in rural areas.

Output of nitrogenous fertilizer increased steadily from 309,000 nutrient tons in 1966/67 to about 829,000 tons in 1970/71. Five large factories currently account for about 60 percent of the output of nitrogenous fertilizer (app. table 7). A large new fertilizer complex at Visakhapatnam, Andhra Pradesh, contributed significantly to the rise in output in 1968/69 and 1969/70. Production from the new factories at Gorakhpur, Kanpur, and Kotah in the late 1960's helped ease the shortage of fertilizer in wheat-growing areas.

The Fertilizer Corporation of India, a public corporation, manages more than half the country's factories that produce nitrogenous fertilizer. During 1972, three new factories will begin operations under FCI, with each plant having a production capacity of 330,000 tons of urea annually.

Nitrogenous fertilizer output in 1972 is expected to be 40 percent higher than the 1971 level. A gradual increase in the use of production capacity completed in the last several years, plus the new factories scheduled to open, should enable Indian manufacturers to produce about 1.2 million tons of nitrogenous fertilizer in 1971/72. Appendix table 7 shows the output of nitrogenous fertilizer by major location since 1966/67 and prospects for output during 1971/72-1973/74.

India's output of phosphate fertilizers in 1970/71 was only 20 percent above the 1967/68 level. Four large new factories accounted for about half the production capacity. They produce complex fertilizers containing both nitrogen and phosphorus. About 28 smaller factories produce superphosphate, relying upon imported phosphate rock. Utilization of commercially valuable phosphate deposits in Rajasthan should enable some manufacturers to gradually shift to domestic raw materials.

Prospects for opening more large new fertilizer factories will depend upon how rapidly factories constructed with the use of foreign investments and engineering are completed. Some of these include the Indian Farmers Fertilizer Cooperative, Ltd., at Gujarat; the Zuari Argo Chemicals, Ltd., factory at Goa; and the Dharmsi Chemical plant near Bombay. Numerous small factories are also being built. (See fig. 3 for the location of major factories now operating).

Two new coal-based fertilizer plants are planned by FCI. Work on the first plant, at Talcher in Orissa, began in February 1970. Construction of the second plant, at Ramugundam in Andhra Pradesh, began in October 1970. Each plant will cost an estimated $94.6 million to build and, when completed, each will have an annual capacity for producing 495,000 tons of urea. The plants are scheduled to begin production in 1974/75.

Imports

Before 1967/68, demand for fertilizer among Indian farmers greatly exceeded domestic production. Imports of manufactured fertilizer increased from 492,000 nutrient tons in 1965/66 to a peak of 1.6 million nutrient tons in 1967/68, when the value was about $250 million. After 1967/68, a downward trend in imports occurred, particularly imports of certain types of nitrogenous fertilizer, which were being produced in larger quantities by local factories. Since 1969,

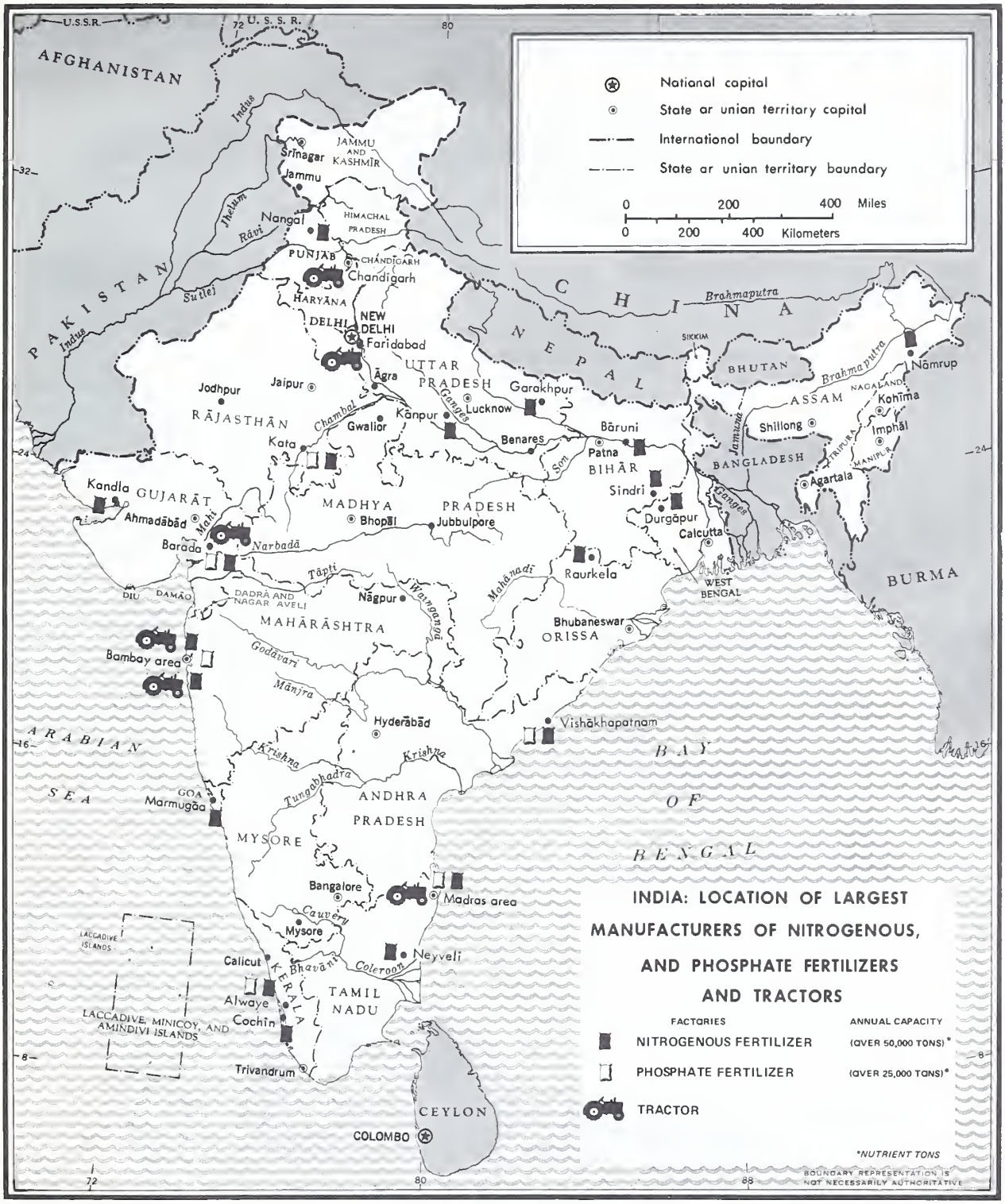


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Figure 3

a shift to imports from Eastern Europe has occurred because changes in financial arrangements caused imports from the United States, Western Europe, and Japan to decline.

The share of total fertilizer supplies accounted for by imports declined from about 73 percent in 1967/68 to about 40 percent in 1970/71. Stocks of fertilizer held by dealers have increased considerably since 1968. Many small farmers began to participate in the Green Revolution only after fertilizer became available in their villages.

Use

The Fertilizer Association of India recently estimated that 40 percent of the farmers use some fertilizer (22). Most of the traditional subsistence farmers, however, have not yet started to use fertilizer. Of the farmers who use fertilizer, over 90 percent use less than half the recommended level on cereal crops, with particularly low levels of phosphate and potash applications (13). Fertilizer use in the first three 5-year plans fell short of target levels.

Total fertilizer use increased from 305,000 nutrient tons in 1959/60 to 2.2 million nutrient tons in 1970/71 (fig. 4 and app. table 8). Use of large quantities of fertilizer for grains and other cash crops is a relatively new development in India (25 years ago, producers of beverage crops & tobacco were the leading users of fertilizer). Growth in fertilizer use in the late 1960's was associated with the rapid spread of high-yielding cereal varieties. In 1967/68,

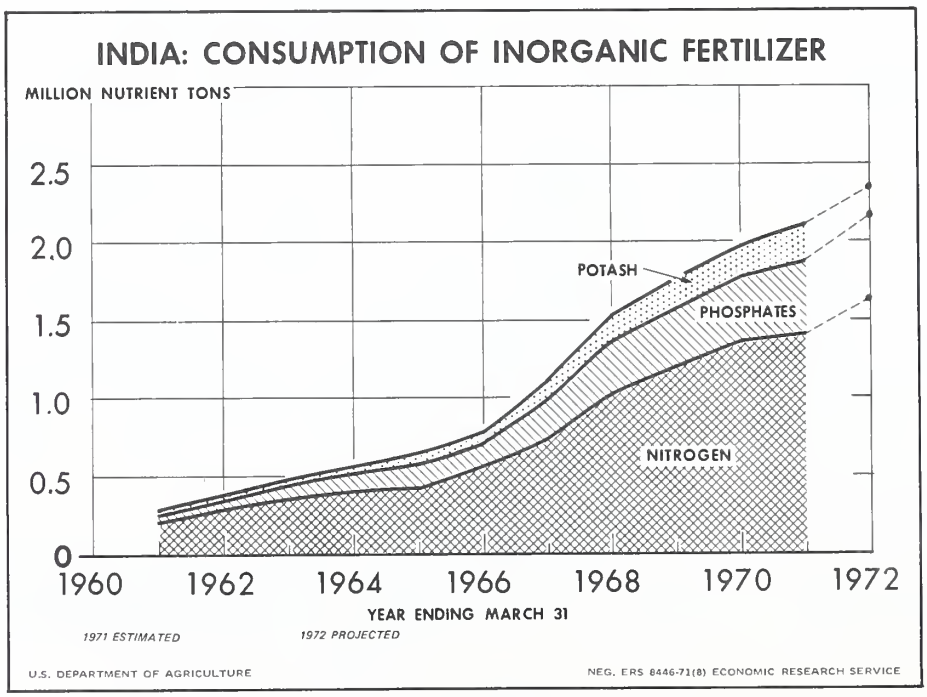

Figure 4

fertilizer supplies were somewhat limited, however, and only farmers living in certain districts and planting high-yielding varieties were allowed to buy fertilizer.

Of total fertilizer applications in India, grains receive about two-thirds of the nitrogen and over half of the phosphate and potash applications. Yet, over half the area planted to grains receives no chemical fertilizer. Rice area receives about 34 percent of all nitrogenous fertilizer applications. Of this, approximately 18 percent is used in irrigated rice areas and 16 percent in rice areas with assured monsoon rainfall (2). High-yielding rice varieties receive about half the fertilizer used on rice. Wheat receives about 12 percent of the nitrogen and over 10 percent of the other chemical nutrients applied on all crops.

Table 3.--Estimates of the share of nitrogenous fertilizer used on specified crops, India, 1970/71

Crop	Irrigated area	Unirrigated area	Total
		Percent	
Rice	18.2	15.8	34.0
Wheat	6.9	5.1	12.0
Grain sorghums	0.6	7.1	7.7
Bajra	0.3	5.6	5.9
Corn	0.2	1.6	1.8
Barley	1.3	0.7	2.0
Ragi	0.3	0.7	1.0
Other grains	1.0	1.2	1.3
Total grain	27.9	37.8	65.7
Pulses	1.1	5.5	6.6
Total food grains	29.0	43.3	72.3
Sugarcane	8.0	0.0	8.0
Cotton	1.7	3.5	5.2
Spices	2.5	1.8	4.3
Vegetables	2.9	0.9	3.8
Tobacco	0.6	0.4	1.0
Other	2.9	2.5	5.4
Total	47.6	52.4	100.0

Source: Calculated from (2).

Sugarcane is the major recipient of fertilizer among the nongrain crops. It accounts for about 8 percent of the nitrogenous fertilizer applied and ranks first among major cash crops in the rate of fertilizer application per hectare (2).

Credit for fertilizer purchases by farmers from cooperatives and new branches of the 14 nationalized banks increased about 25 percent during 1968-71 (12). Yet, difficulty in obtaining adequate credit remains a major deterrent to expanding fertilizer sales to small farmers.

A 10-percent excise tax was put on fertilizer in March 1969 by the Government of India (3). Railroad rates for hauling fertilizer have been increased at a much greater percentage than rates on most other commodities. New regulations and added costs for truck owners have caused them to increase their fee for hauling fertilizer from railway depots to village distributors.

Prices

Prices paid by farmers for fertilizer have tended to increase in recent years, particularly for certain types of nitrogenous fertilizer (table 4). The closing of the Suez Canal and uncertainty about continued imports of phosphate rock caused the price of superphosphate to increase by 25 percent between 1966 and 1968. Competition from other types of fertilizer caused the price for superphosphate to decline in April 1970 to near the 1966 level. However, the price recovered in late 1970 because of greater use by wheat farmers.

Table 4.--Prices paid by farmers for selected types of fertilizer, India, 1966-70 1/

Type	1966	1967	1968	1969	1970
	Dollars per metric ton				
Urea (46% N)	90.67	112.00	114.67	125.73	125.73
Ammonium sulphate	54.00	65.60	66.93	71.87	70.53
Ammonium sulphate nitrate	68.67	76.93	76.93	83.47	83.47
Calcium ammonium nitrate	48.67	58.26	58.26	63.07	58.27
Superphosphate	34.78	40.13	41.56	39.96	36.59
Muriate of potash (60% K_2O)	41.87	52.26	58.60	63.73	64.40

1/ Years beginning Feb. 1.

Source: (3, Jan. and Sept. 1971).

Economics of Fertilizer Use

Many experiments have proven the advantages of using fertilizer in combination with certain high-yielding seed varieties and cultivation methods. The optimum level of fertilizer application (the level that provides the highest profit) for semi-dwarf Mexican wheat varieties ranges from 20 to 80 percent

above that recorded for the best tall Indian variety. Tests by ICAR showed that the optimum dose of nitrogen for Sharbati Sonora, a popular amber-colored adaptation of Mexican wheat, is 124 kilograms per hectare (table 5) (3, Jan. 1971). In comparison, only 69.6 kilograms of nitrogen per hectare are needed to obtain a maximum yield of C 306--a tall India wheat. With optimum nitrogen applications, the maximum yield for Sharbati Sonora was 4.4 tons per hectare, 40 percent above the maximum yield for C 306.

When large quantities of fertilizer are applied to tall Indian varieties of wheat and rice, these varieties tend to suffer from lodging and fall to the ground before havrest time. Conversely, Mexican wheat varieties and Philippine rice varieties have stronger and shorter stems and are much less prone to lodging (1).

The response of new rice varieties to nitrogen varies according to the time and rate of application (table 6). Yields of grain sorghum and Bajra also vary according to the amount and timing of nitrogen application (tables 7 & 8).

Experiments have proven that extra profit can be obtained by adding potash fertilizer to various crops where only nitrogen and phosphorus were included previously.

Table 5.--Yields of selected varieties of wheat obtained when the optimum dose of fertilizer was applied, India, 1969/70 1/

Variety of wheat	Optimum dose	Yield at optimum dose	Response over no nitrogen	Net profit per hectare with optimum dose of fertilizer
	Kgs. of nitrogen per hectare	Kilograms	Kilograms	Dollars
Sharbati Sonora	124.0	4,415	2,225	203.75
S 227	95.2	3,949	1,571	141.78
S 308	105.2	3,694	1,475	129.00
PV 18	95.2	3,821	1,441	127.94
Chhoti Lerma	105.2	3,817	1,631	145.50
Sonora 64	118.0	3,888	1,748	154.54
Lerma Rojo	92.0	3,596	1,221	105.47
J 227	92.8	3,652	1,172	100.00
Safed Lerma	89.6	3,422	1,223	106.27
C 306	69.6	3,154	785	65.00

1/ From tests conducted near Delhi by the Indian Council of Agricultural Research (ICAR).

Source: (3, Jan. 1971, p. 47).

Table 6.--Yields of Padma and Sabarmati rice varieties obtained when the rate and time of nitrogen application is varied, India, 1969 1/

Treatment number	Fertilizer application at time of--			Total fertilizer application	Grain yield of--	
	Planting	Cultivation	Panicle initiation		Padma	Sarbarmati
	Kilograms of nitrogen per hectare				Kilograms/hectare	
1	0	0	0	0	3,395	2,925
2	40	20	20	80	4,616	4,637
3	100	0	0	100	5,130	5,574
4	75	25	0	100	6,315	5,207
5	75	0	25	100	5,916	4,601
6	50	0	50	100	4,968	4,345
7	50	50	0	100	6,488	5,986
8	50	25	25	100	5,676	4,813
9	25	75	0	100	6,534	6,532
10	25	50	25	100	6,053	4,862
11	0	100	0	100	6,168	6,282

1/ From tests conducted near Delhi by the Indian Council of Agricultural Research.

Source: (3, Jan. 1971).

Table 7.--Average yields of four varieties of grain sorghums obtained at different levels of nitrogenous fertilizer applications, India, 1969 1/

Kilograms of nitrogen per hectare	H-I	H-II	Swarna	Local
	Kilograms per hectare			
0	1,880	1,930	1,390	1,460
50	2,930	2,650	2,470	2,210
100	3,820	3,220	3,200	2,110
150	3,870	3,500	3,210	2,280
200	3,900	3,830	3,580	1,490

1/ From tests conducted at the Dharwar research station by the Indian Council of Agricultural Research.

Source: (3, Jan. 1971).

Table 8.--Average yields of three varieties of bajra obtained at specified levels of nitrogenous fertilizer application, India, 1969 1/

Kilograms of nitrogen per hectare	HB 1	HB 4	Local
	Kilograms per hectare		
0	1,160	1,520	930
40	1,610	2,050	1,250
80	2,080	2,460	1,490
120	2,240	2,640	1,630
160	2,370	2,760	1,790
200	2,460	2,830	1,750

1/ From tests conducted at the Dharwar research station by the Indian Council of Agricultural Research.
Source: (3, Jan. 1971).

Irrigation

India ranks next to the People's Republic of China as the second most important country in the world in irrigated cropland. The total area under irrigation currently covers 32 million hectares. The proportion of all cropland receiving irrigation increased from 16 percent in 1950 to 23 percent in 1970. More than one crop is planted annually on about one-fourth of the irrigated land, and future gains in multiple-cropping are closely tied to an expansion in irrigation. Installation of new tube-wells and construction of new irrigation canals is proceeding rapidly in the Gangetic Plain. Total irrigated area has been expanding by about 1 million hectares annually.

Indian cultivators currently obtain about 41 percent of their water from irrigation canals, 34 percent from wells, 17 percent from tanks (ponds), and the remaining 8 percent from other sources (22). The share of irrigation water obtained from canals has declined in recent years as more tube-wells have been installed. Natural streams, springs, and underground tiles provide some irrigation water. The number of diesel and electric pumps used by farmers increased from 979,000 in 1965/66 to about 2 million in 1970/71. Most of the investments in small irrigation facilities are private, while major projects are financed by the Government.

During the first three Five-Year Plans (covering, in all, 1950/51-1965/66), the Government allocated $3.2 billion to about 500 irrigation projects. Of these, 295 projects providing 4.2 million hectares of additional irrigated land had been completed by 1966. Expenditures during the first three plans totaled $1.8 billion for major and medium schemes and $800 million for minor schemes. During the Fourth Five-Year Plan (1969/70-1973/74), programs designed to add 10 million hectares to irrigation are scheduled, but actual accomplishment is likely to be below the target level (20).

In most areas--particularly northwestern India--unpredictability in the timing and amount of rainfall received from June through September have caused many farmers to install irrigation facilities. Low average yields for cotton and oilseed crops have prevailed in western India because of the lack of adequate irrigation facilities.

Farmers are using tube-wells to tap more of the vast underground water resources. Over 400,000 tube-wells are now operated in the Gangetic Plain, compared with less than 100,000 in 1965. It has been estimated that tube-wells and other facilities for developing minor irrigation could add 18 million hectares of irrigated land by 1982 (20). Most of the expansion would occur on the alluvial soils of Punjab, Uttar Pradesh, Bihar, and West Bengal.

Since 1965, India's Exploratory Tube-wells Organization has evaluated actual and potential underground water reserves. Large supplies of water near the surface were found in the northern part of the Gangetic Plain and north of Calcutta. Plans have been completed for building facilities to use this water for urban needs and for irrigating vegetable gardens located near the city. The Narmada Valley of Madhya Pradesh has a large storehouse of ground water. Considerable reserves of ground water were recently found in the Jaisalmer area of the Thar Desert of Rajasthan (20).

Some of the largest dams that provide irrigation water are Ghakra (Punjab), Kosi (Bihar), Hirakud (Orissa), Gandi Sagar (border of Madhya Pradesh and Rajasthan), Nagarjunasagar (Andhra Pradesh), and Mahi (Gujarat) (10).

Farm Labor and Land Ownership

About 164 million Indians or nearly 69 percent of the total labor force were employed in agriculture in 1970. Employment in the farm sector is increasing by about 2.1 percent annually, compared with 5.5 percent in the nonfarm sector.

Farm wages in India range from $2 a day for tractor drivers in the Punjab to less than 20 cents a day for some women and children in southern India. 5/ The average wage for all farmworkers in India is currently about 35 cents a day, or 4 cents an hour.

Subsistence farmers with an average of less than 2 hectares of land account for about 60 percent of all farmers in the country (5). They perform all of the work on their small farms and still seek some off-farm employment. About 14 percent of the farmers own more than 5 hectares and they provide most of the employment for landless laborers (18).

5/ See app. table 8 for variations in labor and draft animals required for various crops and work activities.

Millions of Indians migrate from rural to urban areas each year, causing severe unemployment problems in urban areas. Government programs are assisting these persons in finding employment. For agricultural workers, the Government is promoting multiple-cropping, rural work projects, and cottage industries as a means of providing employment throughout the year (7, Oct. 1970). The Government-sponsored Small Farmers Development Agency and Marginal Farmers Program are designed to carry some of the benefits of the Green Revolution to small farmers.

During 1960-70, tenant farmers received deeds to 1 million hectares of land that was redistributed after land-ceiling laws were passed. This redistributed land accounts for less than 1 percent of the country's cropland. Most of the breakup of large farms resulted in farmers selling or giving part of their land to their family members or relatives, rather than transferring it to tenant families (18). Land-ceiling laws vary by states and the availability of irrigation water. While larger farms have been divided in most of eastern India to comply with these laws, medium sized commercial farms have increased in size in the Punjab. Between 1955/56 and 1967/68 in the Punjab, holdings of farms ranging from 40 to 60 hectares increased by 40 percent. Relatives of owners often share in these holdings.

Tenant farmers now cultivate about 32 million hectares of land. Where tenants provide all of the inputs except the land resource, the landlord usually receives about one-third of the value of the harvest. Opportunities for good profits from the use of new technology have enticed some landlords or their children to become cultivators themselves, replacing the tenant. Very little land is available for sale at any given time. Irrigated land that sold for $650 to $1,600 per hectare in northern India 5 years ago now sells for three to five times that amount (18).

Machinery and Equipment

In early 1972, India had 130,000 tractors in operation and the number is increasing by 40,000 annually. The tractors are used mostly to prepare seedbeds for planting wheat and other grains. It is less costly to hire custom tractor plowing than to pay the wages of workers spending many days preparing the land with bullocks and wooden plows. A tractor used in preparing the seedbed for wheat can cover as much area in 1 day as can 100 men using traditional hand tools.

Garden tractors imported from Japan and Eastern Europe are becoming more common in coastal rice-producing areas. Over 20,000 two-wheel garden tractors and rotary tillers were used in early 1972. Small tractors are more suitable for small fields, where rice bunds pose a problem for larger, four-wheel tractors. Some researchers have indicated that Indian farmers with small acreage can cooperatively share a garden tractor and save money by selling their bullocks (8).

The advantages of farming with tractors are realized by more Indian farmers each year, especially in northwestern India. In addition to contributing to greater crop productivity and profits, tractors help farmers to more easily

Once wheat is harvested, tractors are used to quickly plow the fields to prepare the soil for another crop. Such use of tractors has spurred the practice of multiple-cropping in India.

cultivate cloddy soil, which is difficult to work with traditional methods. Also, because they are time-saving, tractors enable farmers to plant and harvest their crops at the proper time. Implements used with tractors allow farmers to quickly and easily distribute fertilizer, seed, and insecticides at the proper time.

Many progressive Indian farmers contend that the use of a tractor and farm implements has been a major factor contributing to their higher incomes, to more intensive use of multiple-cropping, and to preparation of efficient irrigation facilities. Many farmers without tractors have difficulty preparing irrigation ditches or furrows that will effectively carry water to all parts of the field. Tractors are convenient sources of power for transporting supplies to the farm and for transporting crops to market centers.

Experiments conducted near Delhi by the India Council of Agricultural Research indicated a definite advantage of using tractors for obtaining maximum yields from high-yielding varieties and for planting four crops a year. Land previously used to grow fodder crops for draft animals can now be used for profitable new varieties of cereals and potatoes.

Despite the increased use of tractors, the major source of draft power in India is still bullocks. About 70 million are used to cultivate fields. However, more farmers are discarding their traditional wooden plows and using more efficient metal plows. Over half the plows in use are still reported to be the wooden type, but they are used to plow less than one-fourth of the land. Some farmers hire custom tractor operators to do the initial plowing and then use their bullocks for subsequent cultivations. Tractors and rotary tillers are used to prepare about 9 percent of the soil for planting, and large hand hoes are used for 5 percent.

Tractor Manufacturing

India's output of four-wheel tractors tripled between 1965/66 and 1969/70, rising from 5,714 to 17,350 units. For the relative importance of major tractor factories, see table 9. Output of four-wheel tractors in 1971/72 is estimated at around 22,000 units. Because of the marked rise in the use of high-yielding cereal varieties and profits obtained from them, use of tractors has increased rapidly (fig. 5).

India's tractor output could reach 40,000 four-wheel tractors in 1973/74 (3, Jan. 1971). In addition to the four large factories which together produced 17,000 tractors in 1969/70, new factories under construction near Bombay and in Haryana will enable output to reach 27,000 in 1972/73. Additional factories are scheduled for construction in the Punjab and in Haryana. While medium sized, 28 to 35 horsepower, four-wheel tractors have been prevalent in the last decade, the variety of tractors available is expected to increase in the future.

Table 9.--Output of 4-wheel tractors, by specified factories, India, 1965/66 through 1969/70 1/

Factory	1965/66	1966/67	1967/68	1968/69	1969/70
			-Number-		
Escorts, Faridabad	1,258	2,133	2,556	5,625	8,000
Eicher, Faridabad	123	92	204	346	350
International, Bombay	--	1,301	2,901	4,001	4,200
Massey-Ferguson, Madras	3,066	3,397	4,087	3,275	3,100
Hindustan, Baroda	1,267	1,893	1,646	2,219	1,700
Total	5,714	8,816	11,394	15,466	17,350

1/ Years beginning April 1.
Source: (16).

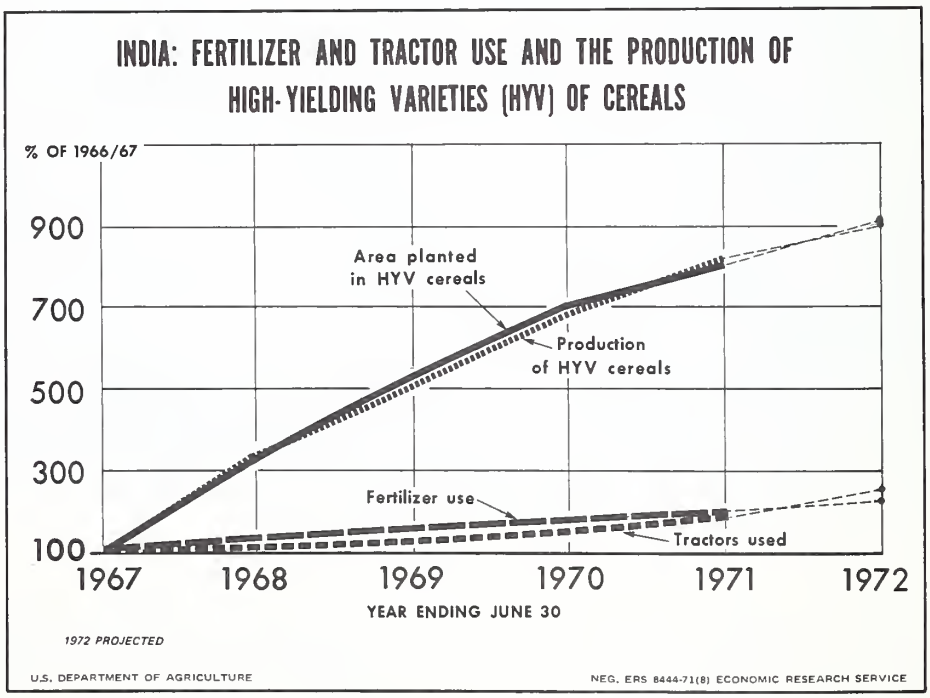

Figure 5

Tractor Imports

India's tractor imports in 1971 approximated 20,000, compared with only 7,500 in 1968. The Government-owned State Trading Corporation (STC) handles tractor imports. In recent years, most of the imports have been received by STC through trade agreements with the Soviet Union and East European countries. Some large models have been imported from the United States, especially for irrigation projects and land clearing.

Soviet exports of tractors to India increased from 1,703 in 1968 to 6,140 in 1969 and continued at high levels in 1970 and 1971. East Germany sent about 9,000 tractors to India in 1969 and 1970. Over 30,000 Czech tractors have been imported since 1948. Yugoslavia sends 600 to 1,200 medium sized tractors to India annually. Poland exported 6,552 tractors to India in 1969.

Pesticides and Insecticides

In India, losses of all grain from pests--from the time of planting the crop until use by consumers--are estimated at 7 to 10 percent of production. Adequate control measures could greatly reduce these losses. Some pesticides were used on over 45 million hectares of cropland in 1970/71, compared with only 2.4 million hectares in 1955/56.

Of the 50,000 tons of pesticides used by Indian farmers in 1970/71, about 70 percent was produced domestically. The private sector accounts for over 90 percent of pesticide output. Important insecticides manufactured in India are BHC, DDT, Thiocarbamate, Malathion, and Thiram.

The recent trend in insecticide imports has been a shift to ingredients for use in Indian factories rather than imports of ready-to-use insecticides. About one-fourth of the ingredients used by domestic producers are imported. Imports of insecticides ready for immediate use by farmers usually range between $10 million and $15 million. The United States, Switzerland, the United Kingdom, and Japan are the major suppliers.

Several years ago, crops in western India were severely attacked by locusts. This and other massive attacks by insects prompted the Government to purchase airplanes for use in spraying crops in such emergencies. Aerial spraying of insecticides to control malaria has added several million hectares of new cropland in Uttar Pradesh. Plans to use airplanes for spraying cotton are included in programs to boost cotton yields. The Fourth Five-Year Plan's target for aerial spraying includes 2 million hectares of cropland.

Seed treatment, which is the first stage of plant protection, has spread rapidly in India. In 1971, it affected seed planted on 26 million hectares. During the Fourth Five-Year Plan, various types of plant protection are scheduled for about 82 million hectares of cropland.

Some new rice varieties have been more susceptible to certain severe diseases than traditional rice varieties, although traditional varieties suffered for centuries from fungal diseases, blast, and Helminthosporiose. However, traditional varieties seldom were attacked by streak, the bacterial blight disease, which destroyed entire fields of IR-8 and some other high-yielding varieties in the late 1960's. In 1969, an epidemic of Tungro (a virus disease) hit high-yielding rice varieties in Uttar Pradesh and Bihar.

Other Selected Inputs

Also important to the expansion of agricultural production in India have been developments outside the realm of direct, physical inputs. The indirect inputs discussed here--farm credit and agricultural research, education, and training--have affected the type and magnitude of the more direct inputs, such as fertilizer and irrigation.

Farm Credit

Most of the farm credit in India has gone to large farmers, especially the 7 percent who own about half the nation's cropland. For smaller farmers, scarcity of credit has hindered the use of farm inputs. Since most efforts to provide credit in the past have not reached the mass of small farmers, new programs have been designed to give them credit and a chance to share in the Green Revolution. Providing credit and technical assistance to small farmers is a major function of the Small Farmers Development Agency.

The expansion of farm cooperatives in India has resulted in increased availability of credit for individual farmers. Cooperatives now provide almost one-third of the loans received by farmers. Land-mortgage banks provide about 9 percent, and private individuals and moneylenders provide over half. Relatives of farmers working in cities, in the military, or abroad often send money home for investment in the family farm. Moneylenders are usually larger farmers or relatively wealthy merchants who reside in rural areas.

In 1967/68, primary agricultural credit societies provided credit for some farmers in 86 percent of India's 550,000 villages. These societies, which numbered nearly 150,000, contained 28 million members and served 32 percent of India's rural families (12, Nov. 1970).

In July 1969, the Government of India nationalized the 14 largest banks in the country. Banks--excluding land mortgage banks--provided about 5 percent of the credit received by Indian farmers in 1970. Plans to greatly increase the activities of these banks in providing loans to farmers are beginning to materialize (12, Nov. 1971).

Research, Education, and Training

The Indian Council of Agricultural Research is the major coordinator of research designed to increase crop yields, improve farming methods, provide rural employment, and increase farm income. ICAR was established in 1929. It was reorganized in 1965 and now has 25 research institutes and 8 Soil Conservation Research and Training Centers under its control (9).

Education in agriculture and sciences related to agriculture is increasing rapidly now that 30 percent of the people are literate. There are now 12 agricultural universities, 73 agricultural colleges, and 20 veterinary colleges. Short courses for extension agents and farmers are conducted by these institutions. Demonstrations centers illustrate improved farming methods to millions of visitors each year. Publications and information provided for radio programs by universities and colleges arouse enthusiasm and spread knowledge among farmers.

OUTLOOK FOR TECHNOLOGICAL CHANGE

During 1971-81, total agricultural production in India is expected to increase slightly faster than population because of the continued spread of new technology. The population is now increasing about 2.4 percent annually, but a slight decline in the growth rate is anticipated for the late 1970's. The area planted to high-yielding grain varieties is expected to reach 30 million hectares in 1981--double the area planted in 1971. Fertilizer use is expected to more than double, with domestic factories providing an increasing share of farm needs. The area covered by multiple-cropping in 1980 is expected to approximate 35 million hectares, about 50 percent above the 1970 level. Area under irrigation is expected to increase by about 1 million hectares per year in the 1970's. Indian farmers will be operating about half a million four-wheel tractors and about 140,000 garden tractors by 1980.

Use of new technology is expected to result in a 4-percent annual increase in grain production in India during 1971-81. (Projections of grain production are discussed in the following sections.) New technology will also have a marked impact on the production of cotton, peanuts, soybeans, castor beans, and vegetables. Critical shortages of cotton and vegetable oils have caused Indians to step up programs designed to spread the use of high-yielding varieties of cotton, peanuts, and other oilseeds. By 1980, oilseed production should exceed 14 million tons and vegetable production is expected to approximate 45 million tons. India is likely to be a net grain exporter during several years of the 1970's.

PROJECTIONS OF GRAIN PRODUCTION IN INDIA

The following sections present projections of food grain production and total grain production in India. In the present study, projections were made for 1971/72, 1972/73, and 1973/74 (the last 3 years of the Fourth Five-Year Plan) and for 1980/81. This study's projections for 1980/81 are compared with projections made in other studies.

Methodology and Assumptions

Projections for most of the food grains (all cereals and pulses) were made on the basis of expected growth rates in area and yield, which were calculated separately for high-yielding and traditional varieties. Production of barley and pulses was projected only for traditional varieties, because no statistics are available to indicate the extent of high-yielding varieties planted in these crops.

The expected rate of farmers' adoption of new technology is considered in the projections. Past trends in area planted to high-yielding varieties (HYV's) provided some useful indicators, but limitations on the further spread of HYV's were also considered. The rate of increase in the area planted to high-yielding varieties is expected to slow down, because much of the best land is already being used for such production.

The availability of fertile soil, irrigated area, fertilizer supplies, and other inputs was considered. Fertilizer use will continue to expand, but at a less rapid rate than in the last 5 years. When HYV's were first planted in areas where little fertilizer was used, 1 nutrient ton of fertilizer was expected to provide an additional 13.5 tons of grain (14). The use of 1 additional nutrient ton of fertilizer on HYV's already receiving 30 percent of the recommended dose could provide an additional 10 tons of grain, according to the National Council of Applied Economic Research (NCAER) in New Delhi. Since levels of fertilizer use in India are still relatively low, few farmers yet face the problem of a diminishing rate of return.

The projections considered a shift to newer high-yielding varieties that have more resistance to disease and insects and that require shorter growing seasons. New farming areas made available through irrigation projects and new programs to encourage more small farmers to use HYV's were also taken into account.

Projections of area and average yields assume that prices for wheat and coarse grains will maintain their high levels and that rice prices will increase by 2 to 3 percent annually during 1971-81. Normal weather is assumed, although droughts are likely to reduce production in 2 out of every 10 years, even with the new insurance provided by HYV's planted in irrigated areas.

Projections

India's food grain output (all cereals and pulses) in 1973/74, the last year of the Fourth Five-Year Plan, is projected at 123.2 million tons (app. table 10). Output in 1980/81 is projected to approximate 144 million tons--about 33 percent above the bumper harvest of 107.8 million tons in 1970/71 (app. table 11).

Total cereal production (excludes pulses) is projected at 110.5 million tons in 1973/74 and 129.3 million tons in 1980/81. The difference between total food grain output and total cereal output is production of pulses--projected at 12.7 million tons in 1973/74 and 14.5 million tons in 1980/81. Most of the additional cereal production will come from high-yielding varieties planted in areas that are irrigated or that have assured rainfall. The share of grain production provided by high-yielding varieties is expected to increase from 35 percent in 1970/71 to about 45 percent in 1973/74 and approximately 52 percent in 1980/81.

Area planted to high-yielding grain varieties is expected to approximate 30 million hectares in 1980--double the area planted in 1971. Growth in area planted to high-yielding grain varieties and growth in their average yields are projected to be more rapid during the Fourth Five Year Plan--which ends in 1973/74--than during the late 1970's. The loss of area by traditional varieties to HYV's will also proceed at a slower pace after 1974.

The continued increase in area planted to high-yielding varieties will contribute to a rise in multiple-cropping, especially when short-duration varieties are used. An Iowa State University study (17) projected that the area covered by multiple-cropping in India would increase from 25 million hectares in 1970/71 to almost 42 million hectares in 1980/81.

During this period, the total area of cropland in India is expected to increase by only 2 or 3 percent. Because of the advance in multiple-cropping, the decline in area planted to traditional grain varieties will not decline in proportion to increased plantings of high-yielding varieties.

Expansion of area planted to new varieties will create a greater need for fertilizer and irrigation water. Most of the nitrogenous and phosphate fertilizer used by Indian farmers in the 1970's will be domestically manufactured, thus preventing shortages that could result from import restrictions. The Fourth Five-Year Plan calls for new fertilizer factories to begin operations by 1973/74. Their production capacity is targeted to bring the country's total fertilizer production capacity to 3 million nutrient tons for nitrogenous fertilizer and 1 million nutrient tons for phosphate fertilizers. However, operational problems will probably limit actual production to about 2 million nutrient tons of nitrogen and 0.4 million nutrient tons of phosphate fertilizers in 1973/74 (app. table 5). All supplies of potash will continue to be imported.

Table 10 compares 1980/81 projections developed in this study with 1980/81 projections made by India's National Council of Applied Economic Research and with 1980 projections of the Food and Agriculture Organization of the United Nations (FAO). In all three projections, rice and wheat production levels are within 2 percent of one another. Apparently, this resulted because all three projection studies used calculations based upon expected gains in the use of HYV's and fertilizer. Plantings of high-yielding wheat varieties were already significant when the NCAER and FAO projections were being made. However, an upsurge in coarse grains production in India in 1970/71 was not reflected in the projections made by these organizations. Calculations in the present study assume that high-yielding varieties of certain coarse grain crops will continue to spread at a rapid rate during the early 1970's. Therefore, coarse grains projections developed in this study for 1980/81 are higher than those made by NCAER and FAO.

Table 10.--Food grain production in India, 1960/61 and 1970/71, and comparison of projections for 1980/81

Crop	Actual production in--		Projections for 1980/81 made by-		
	1960/61	1970/71	Present study	NCAER study 1/	FAO 2/
	Million metric tons				
Rice	34.6	42.4	58.2	58.0	58.0
Wheat	11.0	23.2	32.3	32.0	31.5
Coarse grains	23.7	30.6	38.8	35.0	33.9
Total	69.3	96.2	129.3	125.0	123.4
Pulses	12.7	11.6	14.5	23.0	None made
Total food grains	82.0	107.8	143.8	148.0	None made

1/ 1970 study of India's National Council of Applied Economic Research (15).
2/ 1971 study of the Food and Agriculture Organization of the United Nations (4).

A recent study by the Economic Research Service (ERS) projected 1980 world demand for wheat, rice, and coarse grains (21). Three sets of projections were made: Set I assumed a continuation of 1971 food and fiber policies and allowed for moderate gains in productivity in less developed countries (LDC's). Under sets II and III, respectively, higher and lower rates of agricultural productivity and economic growth were hypothesized for the LDC's. The study delineated the world into 22 regions. One region, an aggregate of South Asia, was composed of India, Pakistan, Afghanistan, and Ceylon.

No direct comparisons are therefore possible between the ERS projections for South Asia and this study's projections for India. However, wheat production projections in this study are close to those in set I of the earlier ERS study. Rice production projections in this study fall about midway between the ERS set I and set II projections. For coarse grains production, the projections in this study are slightly below those of set II in the ERS study. In recent years, technology in coarse grains and rice production in India has increased more rapidly than anticipated in earlier projection studies. Assumptions of set II projections in the ERS study--that is, accelerated economic growth and agricultural productivity in the LDC's--are nearer to the situation that has developed for rice and coarse grains than assumptions of set I.

For all grains, projections in the present study and in the ERS study indicate that India will be importing grain in 1980. Arrangements which provide markets for India's manufactured products in exchange for rice from Nepal, Burma and Thailand are expected to continue. Exports of wheat to Bangladesh are also expected to continue.

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Appendix table 1.--Selected agricultural data, India and the United States, 1970

Item	Unit	India	United States
Total land area	Million hectares	329	936
Excluding rivers and lakes	do.	327	917
Land in farms	do.	174	507
Forest land	do.	62	250
Cropland cultivated	do.	138	122
Cropland idle or fallow	do.	22	25
Pasture and grazing land	do.	14	360
Cropland irrigated	do.	32	14
Population	Millions	538	203
Labor force, total	do.	231	85
Labor force in agriculture	do.	159	4
Agriculture's share of total labor force	Percent	69	5
Number of farms	Millions	54	3
Number of tractors	do.	.1	5.6
Fertilizer use	Million nutrient tons	2	14
Value of agricultural output	Billion dollars	19	49
Land area per farm	Hectares	3	157
Cropland cultivated per farm	do.	2.2	40
Cropland cultivated per farmworker	do.	0.9	35
Workers per farm	Number	3.1	1.2
Value of output per farmworker	Dollars	120	15,000

Sources: (8, 19).

Appendix table 2.--Share of planted area in specified crops, India, selected states, 1969/70 1/

State	Total planted area 2/	Food grains								Peanuts	Cotton	Sugar-cane	Jute	Other crops 3/
		Rice	Wheat	Grain sorghum	Millets	Corn	Barley	Pulses	Total					
	1,000 hectares	Percent												
Andhra Pradesh	12,811	25.8	0.1	21.3	14.0	1.9	--	10.6	73.6	10.7	2.5	1.2	--	12.0
Assam	3,049	73.6	0.4	--	0.2	0.9	--	3.1	78.1	--	0.5	1.1	4.2	16.1
Bihar	11,178	49.1	10.2	0.1	3.7	8.5	2.4	14.7	78.8	0.0	0.0	1.5	1.2	8.4
Gujarat	9,179	5.4	4.7	14.3	21.6	3.2	0.1	4.5	53.8	19.0	17.9	0.4	--	8.7
Haryana	4,619	4.7	19.9	4.6	18.1	2.1	2.8	22.7	74.8	0.2	3.8	3.2	--	17.9
Jammu and Kashmir	894	27.0	23.5	--	2.8	28.7	2.2	5.6	89.8	--	0.1	0.2	--	9.8
Kerala	3,008	29.0	--	0.1	0.4	--	--	1.4	30.9	0.4	0.2	0.3	--	68.2
Madhya Pradesh	19,366	22.3	16.4	12.5	10.0	3.2	0.9	20.0	85.4	2.5	3.6	0.3	--	8.2
Maharashtra	18,863	7.4	4.6	32.3	14.3	0.3	0.0	13.2	72.1	5.1	14.6	1.0	--	7.1
Mysore	10,668	10.4	3.1	29.6	19.4	0.5	0.0	10.8	73.8	7.3	9.8	0.8	--	8.2
Orissa	7,308	62.1	0.2	0.2	4.4	1.0	--	11.0	78.9	0.9	--	0.5	0.6	19.0
Punjab	5,171	7.4	41.8	0.1	3.9	10.9	1.5	9.9	75.6	4.6	7.4	3.0	--	9.3
Rajasthan	13,424	0.8	9.3	8.7	33.0	5.8	3.5	23.5	84.7	1.5	1.7	0.4	--	11.6
Tamil Nadu	7,400	36.4	0.0	9.9	17.3	0.2	--	5.9	69.8	13.3	4.7	1.8	--	10.5
Uttar Pradesh	25,066	18.1	21.4	2.9	7.2	6.0	5.9	15.9	77.5	1.4	0.2	5.6	0.1	15.3
West Bengal	6,993	71.7	3.4	0.0	0.3	0.7	0.9	10.6	87.8	--	--	0.4	6.3	5.6
Union Territories	2,237	39.0	22.4	0.5	4.3	15.8	2.8	4.2	89.2	0.2	0.3	0.6	0.5	9.2
All India	161,234	23.4	10.3	11.5	12.4	3.6	1.7	13.7	76.6	4.5	4.8	1.7	0.6	11.9

1/ Years beginning July 1.
2/ Includes area planted more than once in a 12-month period.
3/ Includes oilseeds, vegetables, orchard crops, spices, tobacco, and plantation crops. Excludes pastures.

Source: (8).

Appendix table 3.--Area planted to high-yielding varieties (HYV's) and traditional varieties of grain, India, 1949/50, 1960/61, and 1966/77-1970/71 1/

Crop	Unit	1949/50	1960/61	1966/67	1967/68	1968/69	1969/70	1970/71
Wheat:								
HYV's	1,000 hectares	--	--	514	2,942	4,793	4,910	6,180
Traditional	do.	9,758	12,927	12,324	12,956	11,165	11,716	11,712
Total	do.	9,758	12,927	12,838	14,998	15,958	16,626	17,892
Percentage HYV's	Percent	0	0	4.0	19.6	30.0	29.5	34.5
Rice:								
HYV's	1,000 hectares	--	--	900	1,800	2,910	4,342	5,501
Traditional	do.	30,519	34,128	34,351	34,637	35,057	33,338	31,931
Total	do.	30,519	34,128	35,251	36,437	37,967	37,680	37,432
Percentage HYV's	Percent	0	0	2.6	4.9	7.7	11.5	14.7
Grain sorghums:								
HYV's	1,000 hectares	--	--	100	400	460	555	933
Traditional	do.	15,513	18,412	17,954	18,023	18,241	18,050	16,502
Total	do.	15,513	18,412	18,054	18,423	18,701	18,605	17,435
Percentage HYV's	Percent	0	0	0.6	2.2	2.5	3.0	5.4
Corn:								
HYV's	1,000 hectares	--	--	210	283	310	452	508
Traditional	do.	3,262	4,407	4,864	5,300	5,406	5,410	5,331
Total	do.	3,262	4,407	5,074	5,583	5,716	5,862	5,839
Percentage HYV's	Percent	0	0	4.1	5.1	5.4	7.7	8.7
Bajra:								
HYV's	1,000 hectares	--	--	60	400	600	1,155	1,769
Traditional	do.	9,259	11,469	12,179	12,408	11,452	11,338	11,138
Total	do.	9,259	11,469	12,239	12,808	12,052	12,493	12,907
Percentage HYV's	Percent	0	0	0.5	3.1	5.0	9.2	13.7
Ragi & small millets:								
HYV's	1,000 hectares	--	--	20	40	86	120	200
Traditional	do.	7,621	6,808	6,880	7,108	6,898	7,396	7,143
Total	do.	7,621	6,808	6,900	7,148	6,984	7,516	7,343
Percentage HYV's	Percent	0	0	0.3	0.6	1.2	1.6	2.7
Barley 2/	1,000 hectares	3,181	3,113	2,825	3,375	2,758	2,765	2,597
Total grain:								
HYV's	1,000 hectares	--	--	1,804	5,865	9,959	11,534	15,091
Traditional	do.	79,113	91,264	90,900	93,036	89,843	90,013	86,356
Total	do.	79,113	91,264	92,704	98,901	99,802	101,547	101,447
Percentage HYV's	Percent	0	0	1.9	5.9	10.0	11.4	14.9

1/ Years beginning July 1.
2/ All traditional varieties.
Sources: (6), (8), (9).

Appendix table 4.--Average yields of high-yielding varieties (HYV's) and traditional varieties of grains, India, 1949/50, 1960/61, and 1966/67-1970/71 1/

Crop	1949/50	1960/61	1966/67	1967/68	1968/69	1969/70	1970/71
	Kilograms per hectare						
Wheat:							
HYV's	--	--	2,486	2,666	2,335	2,481	2,530
Traditional	655	851	821	722	668	675	650
Total	655	851	887	1,103	1,169	1,209	1,299
Rice:							
HYV's	--	--	2,111	2,111	1,993	2,234	2,181
Traditional	771	1,013	831	984	969	922	954
Total	771	1,013	863	1,032	1,076	1 073	1,134
Grain sorghums:							
HYV's	--	--	1,000	1,000	1,109	1,117	1,393
Traditional	378	533	508	535	510	504	417
Total	378	533	511	545	524	522	470
Corn:							
HYV's	--	--	2,000	1,943	1,935	1,991	2,067
Traditional	627	926	920	1,079	944	882	1,194
Total	627	926	965	1,123	997	968	1,270
Bajra:							
HYV's	--	--	1,500	1,500	1,417	1,636	1,809
Traditional	306	286	359	370	258	305	431
Total	306	286	365	405	315	428	620
Other millets:							
HYV's	--	--	1,500	1,500	1,395	1,500	1,525
Traditional	503	550	449	525	469	496	524
Total	503	550	452	530	480	512	551
Barley 2/	708	906	831	1,038	879	982	1,103
Total grains:							
HYV's	--	--	2,116	2,260	1,915	2,332	2,219
Traditional	591	759	683	749	717	677	726
Total	591	759	711	839	837	865	948

1/ Years beginning July 1.
2/ All traditional varieties.
Sources: (6), (8), (9).

Appendix table 5.--Production from high-yielding varieties (HYV's) and traditional varieties of grain, India, 1949/50, 1960/61, and 1966/67-1970/71 1/

Grain	Unit	1949/50	1960/61	1966/67	1967/68	1968/69	1969/70	1970/71
Wheat:								
HYV's	1,000 metric tons	--	--	1,278	7,843	11,191	12,180	15,635
Traditional	do.	6,391	10,997	10,115	8,697	7,460	7,913	7,612
Total	do.	6,391	10,997	11,393	16,540	18,651	20,093	23,247
Percentage HYV's	Percent	0	0	11.2	47.4	60.0	60.6	67.3
Rice:								
HYV's	1,000 metric tons	--	--	1,900	3,800	5,800	9,700	12,000
Traditional	do.	23,542	34,574	28,538	33,812	33,961	30,730	30,448
Total	do.	23,542	34,574	30,438	37,612	39,761	40,430	42,448
Percentage HYV's	Percent	0	0	6.2	10.1	14.6	24.0	28.3
Grain sorghum:								
HYV's	1,000 metric tons	--	--	100	400	510	620	1,300
Traditional	do.	5,870	9,814	9,124	9,648	9,294	9,101	6,888
Total	do.	5,870	9,814	9,224	10,048	9,804	9,721	8,188
Percentage HYV's	Percent	0	0	1.1	3.9	5.2	6.4	15.9
Corn:								
HYV's	1,000 metric tons	--	--	420	550	600	900	1,050
Traditional	do.	2,046	4,080	4,474	5,720	5,101	4 774	6,363
Total	do.	2,046	4,080	4,894	6,270	5,701	5 674	7,413
Percentage HYV's	Percent	0	0	8.6	8.8	10.5	15.9	14.2
Bajra:								
HYV's	1,000 metric tons	--	--	90	600	850	1,890	3,200
Traditional	do.	2,835	3,283	4,378	4,585	2,952	3,457	4,800
Total	do.	2,835	3,283	4,468	5,185	3,802	5,347	8,000
Percentage HYV's	Percent	0	0	2.0	11.6	22.4	35.3	40.0
Ragi & small millets:								
HYV's	1,000 metric tons	--	--	30	60	120	180	305
Traditional	do.	3,832	3,747	3,089	3,732	3,232	3,669	3,744
Total	do.	3,832	3,747	3,119	3,792	3,352	3,849	4,049
Percentage HYV's	Percent	0	0	1.0	1.6	3.6	4.7	7.5
Barley 2/	1,000 metric tons	2,251	2,819	2,348	3,504	2,424	2,716	2,865
Total grain:								
HYV's	1,000 metric tons	--	--	3,818	13,253	19,071	26,896	33,490
Traditional	do.	46,767	69,314	62,066	69,698	64,424	60,934	62,720
Total	do.	46,767	69,314	65,884	82,951	83,495	87,830	96,210
Percentage HYV's	Percent	0	0	5.8	16.0	22.8	30.6	34.8

1/ Years beginning July 1.
2/ All traditional varieties.
Sources: (6), (8), (9).

Appendix table 6.--Production and imports of inorganic fertilizer, by type, India, selected years, 1951/52-1970/71, and projections for 1971/72-1973/74 1/

Year	Production			Imports				Total supply of all inorganic nutrients (N, P_2O_5, K_2O)
	Nitrogen (N)	Phosphates (P_2O_5)	Total	Nitrogen (N)	Phosphates (P_2O_5)	Potash (K_2O)	Total	
	1,000 nutrient tons							
First Plan 2/:								
1951/52	11.0	9.0	20.0	30.0	1.0	7.8	38.8	58.8
1955/56	76.9	12.4	89.3	53.4	--	10.3	63.7	153.0
Second Plan 2/:								
1956/57	78.8	17.6	96.4	56.8	--	14.8	71.6	168.0
1960/61	112.0	53.7	165.7	171.9	--	24.8	196.7	362.4
Third Plan:								
1961/62	154.3	65.4	219.7	142.9	0.6	30.4	173.9	393.6
1962/63	194.2	88.3	282.5	229.5	8.0	44.3	281.8	564.3
1963/64	219.1	107.8	326.9	197.7	12.3	64.1	274.1	601.0
1964/65	243.2	131.0	374.2	256.5	12.3	57.2	326.0	700.2
1965/66	237.9	118.8	356.7	376.3	21.8	93.6	491.7	848.4
Annual plans:								
1966/67	309.0	145.7	454.7	574.6	129.2	143.3	847.1	1,301.8
1967/68	402.6	207.1	609.7	975.9	370.8	276.5	1,623.2	2,232.9
1968/69	563.0	213.2	776.2	780.1	90.8	165.2	1,036.1	1,812.3
Fourth Plan:								
1969/70	712.7	221.2	933.9	650.0	89.5	124.0	865.5	1,799.4
1970/71	828.5	223.3	1,051.8	478.4	32.5	120.0	630.9	1,682.7
Projected:								
1971/72	1,237.0	290.0	1,527.0	450.0	140.0	220.0	810.0	2,337.0
1972/73	1,660.0	325.0	1,985.0	435.0	200.0	254.0	889.0	2,874.0
1973/74	1,985.0	415.0	2,400.0	742.0	250.0	250.0	1,242.0	3,642.0

1/ Years beginning Apr. 1.
2/ Data cover years in the Government's Five-Year Plans. For the first and second plans, data for only the beginning and ending years are shown.

Sources: (3), (22).

Appendix table 7.--Estimated output of nitrogenous fertilizer by specified plants, India, 1966/67-1970/71, and projections for 1971/72-1973/74 1/

Factory location	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74
	1,000 nutrient tons							
Sindri, Bihar	90	74	76	79	75	84	104	104
Baroda, Gujarat	--	40	70	111	149	177	207	207
Rourkela, Orissa	39	39	48	31	24	40	70	114
Trombay, Mahashtra	36	44	54	45	53	82	90	120
Gorakhpur, Uttar Pradesh	--	1	47	73	68	72	72	72
Neyveli, Tamil Nadu	28	34	41	41	32	43	63	63
Alwaye, Kerala	25	26	35	32	33	83	83	83
Visakhapatnam, Andhra Pradesh	--	7	52	68	61	108	130	147
Namrup, Assam	--	--	12	26	28	42	76	106
Kota, Rajasthan	--	--	--	80	113	120	120	120
Nangal, Punjab	72	78	77	79	54	72	72	75
Kanpur, Uttar Pradesh	--	--	--	18	107	110	110	130
Madras, Tamil Nadu	--	--	--	--	--	40	120	135
Kandla, Gujarat	--	--	--	--	--	--	56	140
Cochin, Kerala	--	--	--	--	--	32	56	70
Durgapur, West Bengal	--	--	--	--	--	22	50	70
Barauni, Uttar Pradesh	--	--	--	--	--	32	46	55
Bombay (Dharmsi), Maharashtra	--	--	--	--	--	18	35	50
Goa, Goa	--	--	--	--	--	--	32	45
Mirzapur, Uttar Pradesh	--	--	--	--	--	--	14	28
Mangalore, Mysore	--	--	--	--	--	--	32	40
Other	19	60	51	30	32	20	22	11
Total	309	403	563	713	829	1,197	1,660	1,985

1/ Years beginning April 1.

Sources: (3), (11).

Appendix table 8.--Growth in the consumption of inorganic fertilizer, by type and quantity, India, 1952/53-1970/71, and projections for 1971/72 1/

Year	Total	Type of plant nutrient		
		Nitrogen	Phosphates (P_2O_5)	Potash (K_2O)
	1,000 nutrient tons			
1952/53	65.7	57.8	4.6	3.3
1953/54	105.1	89.3	8.3	7.5
1954/55	120.9	94.8	15.0	11.1
1955/56	130.8	107.5	13.0	10.3
1956/57	153.8	123.1	15.9	14.8
1957/58	183.7	149.0	21.9	12.8
1958/59	223.9	172.0	29.5	22.4
1959/60	304.5	229.3	53.9	21.3
1960/61	293.9	211.7	53.1	29.1
1961/62	383.4	291.5	63.9	28.0
1962/63	486.4	360.0	89.9	36.5
1963/64	574.3	407.0	116.7	50.6
1964/65	652.6	434.5	147.7	70.4
1965/66	784.9	575.0	132.2	77.7
1966/67	1,102.3	738.0	248.6	115.7
1967/68	1,540.0	1,035.0	335.0	170.0
1968/69	1,674.0	1,131.0	389.0	154.0
1969/70	1,989.0	1,360.0	420.0	209.0
1970/71	2,177.3	1,487.1	462.0	228.2
1971/72 projected	2,777.3	1,786.0	643.0	344.3

1/ Years beginning Apr. 1.

Sources: (3), (22).

Appendix table 9.--Per-hectare utilization of human labor and bullocks, India, selected areas, crops, operations, and years

Year	Area and crop	Operations						
		Preparatory tillage	Sowing & transplanting	Adding nutrients	Irrigation	Harvesting	Other	Total
		8-hour days worked						
1957/58-1959/60 average	Orissa:							
	Rice--							
	Human labor	18.48	6.94	43.1	1.15	24.53	6.97	101.19
	Bullock labor	25.92	9.43	8.2	--	1.75	15.02	60.32
1957/58-1959/60 average	Andhra Pradesh:							
	Rice--							
	Human labor	13.05	27.99	22.3	3.85	46.33	2.59	116.12
	Bullock labor	20.16	--	3.2	--	15.56	.79	39.71
	Tobacco--							
	Human labor	13.17	28.45	56.8	10.60	129.46	9.28	247.75
	Bullock labor	23.77	.20	11.5	.05	8.75	4.20	48.58
1954/55-1956/57 average	West Bengal:							
	Jute--							
	Human labor	25.45	4.52	88.66	1.00	81.07	--	200.70
	Bullock labor	n.a.	n.a.	n.a.	n.a.	n.a.	--	44.50
1954/55-1956/57 average	Punjab:							
	American cotton--							
	Human labor	14.0	4.2	19.8	8.4	24.1	1.5	82.0
	Bullock labor	26.2	5.7	7.7	1.5	0.2	--	41.3
	Irrigated wheat--							
	Human labor	17.2	5.2	6.7	8.4	29.7	--	67.2
	Bullock labor	31.6	7.9	1.3	6.7	14.8	--	62.3
	Unirrigated wheat--							
	Human labor	9.6	3.7	1.3	--	16.8	--	31.4
	Bullock labor	19.2	6.7	--	--	6.7	--	32.6
1957/58-1959/60 average	Maharashtra:							
	Irrigated jowar (grain sorghums)--							
	Human labor	11.9	2.7	19.8	22.5	28.6	--	85.5
	Bullock labor	27.9	5.9	0.7	43.0	8.7	--	86.2
	Unirrigated jowar--							
	Human labor	8.2	2.2	3.2	--	11.9	--	25.5
	Bullock labor	20.5	3.5	1.0	--	2.2	--	27.2
	Unirrigated bajra--							
	Human labor	6.9	2.7	4.9	--	17.4	--	31.9
	Bullock labor	14.3	4.2	2.0	--	3.2	--	23.7

Source: (10).

Appendix table 10.--Projections of area planted, average yields, and production, high-yielding varieties (HYV's) and traditional varieties of food grains, India, 1971/72-1973/74 1/

Crop	Area planted				Yield				Production		
	1971/72	1972/73	1973/74	Average annual change	1971/72	1972/73	1973/74	Average annual change	1971/72	1972/73	1973/74
	1,000 hectares				Kilograms per hectare				1,000 metric tons		
Wheat:											
HYV's	6,640	7,100	7,560	460	2,547	2,564	2,581	17	16,912	18,204	19,512
Traditional	11,562	11,412	11,262	-150	662	667	672	5	7,654	7,614	7,568
Total	18,202	18,512	18,822	310	1,350	1,395	1,435	--	24,566	25,816	27,080
Rice:											
HYV's	6,201	6,901	7,601	700	2,204	2,227	2,250	23	14,667	15,369	17,102
Traditional	31,431	30,931	30,431	-500	964	995	1,016	21	30,299	30,776	30,917
Total	37,632	37,832	38,032	200	1,168	1,220	1,263	--	43,966	46,145	43,019
Grain sorghums:											
HYV's	1,233	1,533	1,833	300	1,398	1,403	1,408	5	1,724	2,150	2,580
Traditional	16,252	16,002	15,752	-250	445	495	495	0	7,232	7,921	7,797
Total	17,485	17,535	17,585	50	512	574	590	--	8,956	10,071	10,377
Corn:											
HYV's	583	658	733	75	2,098	2,129	2,160	31	1,223	1,401	1,583
Traditional	5,339	5,347	5,355	8	1,022	1,251	1,280	29	5,456	6,689	6,854
Total	5,922	6,005	6,088	83	1,123	1,347	1,386	--	6,679	8,090	8,437
Bajra:											
HYV's	2,019	2,269	2,519	250	1,824	1,839	1,852	13	3,683	4,173	4,665
Traditional	10,938	10,738	10,538	-200	400	421	442	21	4,375	4,521	4,658
Total	12,957	13,007	13,057	50	622	668	714	--	8,958	8,694	9,323
Other millets:											
HYV's	250	300	350	50	1,533	1,541	1,549	8	383	462	542
Traditional	7,093	7,043	6,993	50	524	524	524	0	3,715	3,691	3,664
Total	7,343	7,343	7,343	0	558	566	573	--	4,099	4,153	4,206
Barley 2/	2,607	2,617	2,627	10	1,117	1,133	1,149	16	2,912	2,964	3,018
All grains:											
HYV's	16,926	18,761	20,596	1,835	2,221	2,226	2,233	--	37,592	41,759	45,984
Traditional	85,220	84,090	82,958	-1,142	723	763	777	--	61,644	64,174	64,476
Total	102,148	102,851	103,554	693	971	1,030	1,067	--	99,236	105,933	110,460
Pulses 2/	22,700	23,000	23,300	300	525	535	545	10	11,918	12,305	12,699
All food grains:											
HYV's	16,926	18,761	20,596	1,835	2,221	2,226	2,233	--	37,592	41,759	45,984
Traditional	107,920	107,090	106,258	-842	682	714	726	--	73,562	76,479	77,175
Total	124,846	125,851	126,854	993	890	940	971	--	111,154	118,238	123,159

1/ Years beginning July 1. 2/ Projections made only for traditional varieties.

Appendix table 11.--Projections of area planted, average yields, and production, high-yielding varieties (HYV's) and traditional varieties of food grains, India, 1980/81 1/

Crop	Area planted		Yield		Production
	1980/81	Average annual change 1974/75-1980/81	1980/81	Average annual change 1974/75-1980/81	1980/81
	1,000 hectares		Kilograms per hectare		1,000 M.T.
Wheat:					
HYV's	9,660	300	2,651	10	25,609
Traditional	9,652	-230	693	3	6,689
Total	19,312	70	1,672	34	32,298
Rice:					
HYV's	12,291	670	2,320	10	28,515
Traditional	26,931	-500	1,104	12	29,732
Total	39,222	170	1,485	32	58,247
Grain sorghums:					
HYV's	2,743	130	1,443	5	3,958
Traditional	15,052	-100	495	0	7,451
Total	17,795	30	641	7	11,490
Corn:					
HYV's	1,013	40	2,209	8	2,237
Traditional	5,411	7	1,292	2	6,991
Total	6,354	47	1,452	9	9,228
Bajra:					
HYV's	3,394	125	1,922	10	6,523
Traditional	9,768	-110	403	-4	3,937
Total	13,162	15	795	12	10,460
Other millets:					
HYV's	630	40	1,570	3	989
Traditional	6,573	-60	524	0	3,444
Total	7,203	-20	616	6	4,433
Barley 2/	2,662	5	1,205	8	3,207
All grains:					
HYV's	29,741	1,305	2,281	7	67,831
Traditional	76,049	-988	808	4	61,451
Total	105,780	317	1,222	22	129,282
Pulses 2/	24,140	120	601	8	14,508
All food grains:					
HYV's	29,741	1,305	2,281	7	67,831
Traditional	100,189	-868	758	5	75,959
Total	129,930	437	1,107	19	143,790

1/Years beginning July 1.
2/Projections made only for traditional varieties.